

MARINE ENVIRONMENTAL QUALITY COMMITTEE

1977

by A D McIntyre

Belgium

(P Hovart)

1. The effects of dumping industrial wastes along the Belgian coast on the fish and shrimp stocks and invertebrates were further studied.

*sample*  
The monitoring programme was carried out on two dumping areas for industrial wastes derived from titanium dioxide processes, one area for wastes from the production of thiocarbamates, one area for wastes from the production of proteolytic enzymes and one area for an industrial waste containing 1.5% phenol.

The samples were taken on a two monthly basis by a research vessel. A biological and physico-chemical survey was carried out.

2. The two monitoring programmes on heavy metals in fish and shrimps were continued including the study of fifteen species along the Belgian coast (Rhizostoma pulmo, Alloteuthis subulata, Macropipus holsatus, Asterias rubens, Engraulis encrasicolus, Clupea harengus, Trisopterus luscus, Ciliata mustela, Mullus surmuletus, Ammodytes lancea, Ammodytes lanceolatus, Eutrigla gurnardus, Trigla lucerna, Platichthys flesus, Limanda limanda).

Finally, a study was carried out on the evolution of mercury in Solea solea in the North Sea and the Irish Sea.

3. One toxicity test on an industrial pollutant containing thiocarbamates was carried out in accordance with the Oslo Convention.
4. A bimonthly biological and physico-chemical monitoring of the northern part of the Kwinte Bank, Buiten Ratel and Oostdyckbank where sand extractions have started at the end of 1976, was carried out.

5. A regular monthly survey was carried out to assess the general state of the marine environment. In a fixed grid (see Fig. 1), samples were taken or in situ measurements made at 20 stations to measure the following parameters:-

1. General Oceanography

Temperature, salinity, turbidity, fluorimetry, dissolved oxygen, transparency, meteorological observations.

2. Cycle of biogeneuous elements

Dissolved nutrients, dissolved organic matter (DOM), BOD<sub>5</sub>, particulate organic matter (POM), ratio living POM/detrital POM, phytoplankton, zooplankton, heterotrophic marine bacteria, benthos, POM in sediments and primary production.

3. Cycle of pollutants

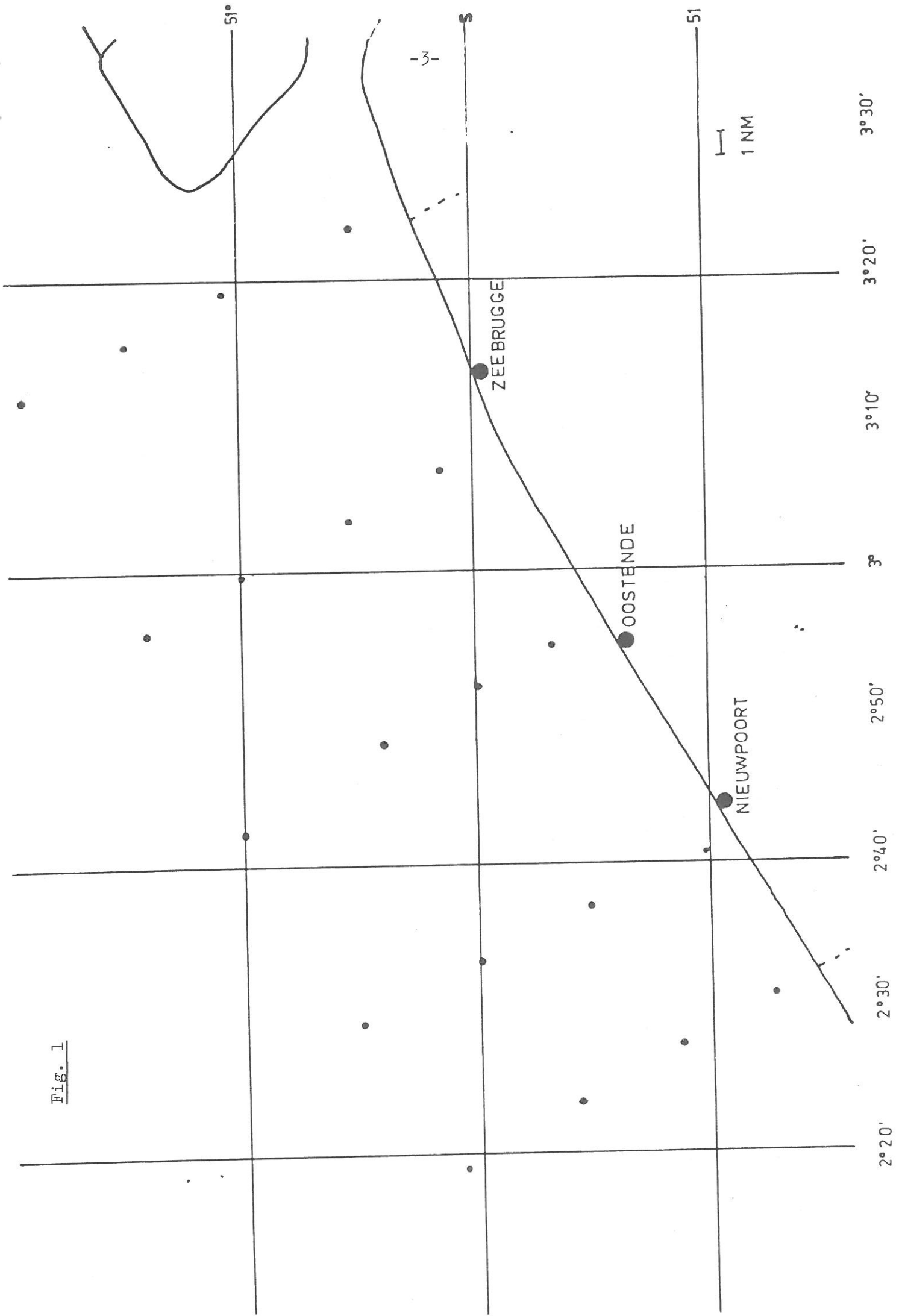
Heavy metals (Zn, Cd, Pb, Cu, Hg) dissolved and particulate, heavy metal content of plankton, heavy metal content of the sediments.

6. A monitoring programme on the Scheldt estuary was continued. Regular monthly surveys of the 36 points indicated on Fig. 2 were made to provide longitudinal profiles of physico-chemical parameters (salinity, temperature, dissolved oxygen, pH, turbidity), to study sedimentation processes and heavy metal transport mechanisms, as well as nutrient interactions and bacterial activity.

7. Special cruises were organized to improve the knowledge of the distribution, the speciation and transformation rates of the organic matter present in the marine environment.

8. Belgium actively participated in an international experiment called "Eurasep", designed to investigate the application possibilities of teledetection as a monitoring tool for chlorophyll, turbidity, etc. The processing of these results is still going on.

Fig. 1



# SCHELDE-ROOSTER

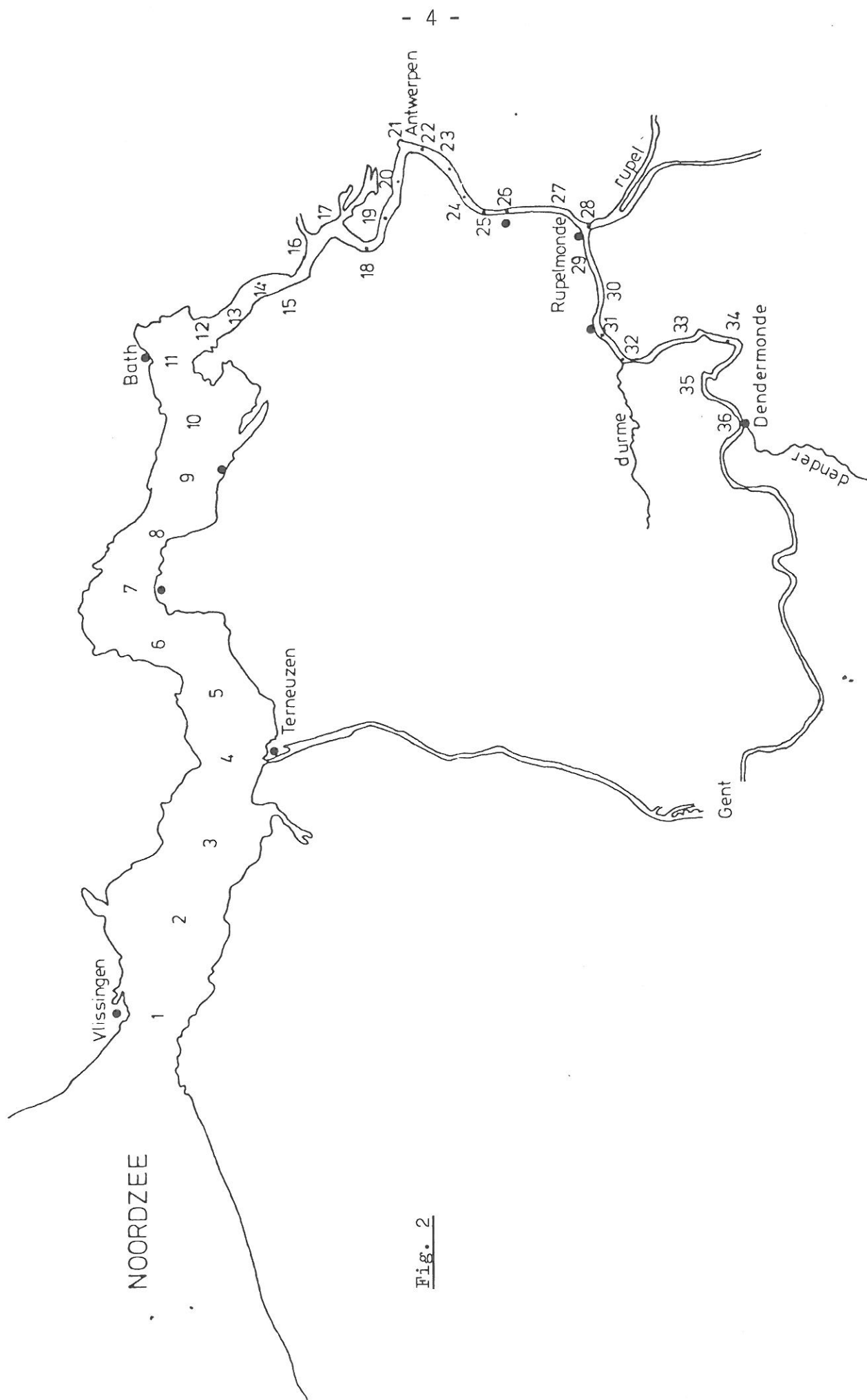


Fig. 2



Canada  
(J.F. Uthe)

POLLUTION CHEMISTRY

1. Further studies on the nature of metals in shellfish showed that:
  - a) Cadmium is tightly bound in scallop adductor muscle and lobster digestive gland, but in oyster about half of the total cadmium is present as free, polarographically active cadmium.
  - b) A variety of metals, both biologically required and toxic ones, show high positive correlations with each other. For example; silver (a toxic metal of no known biological role) levels correlate with copper (a required element of major importance in shellfish) with a coefficient of greater than .95.
  - c) Feeding experiments have shown that cadmium in canned lobster hepatopancreas is taken up by rats at only about one-half the rate of cadmium chloride. The factors which decrease absorption are heat-stable and not the known ones. Further studies are being carried out.
2. Samples of Littorina littorea, Mytilus edulis, Mya arenaria and associated sediments were collected from the inter-tidal zone around the coast of New Brunswick, Nova Scotia and Prince Edward Island. They were analyzed for PAH by IR and fluorescence spectroscopy and GC-MS.
3. Information was compiled on the analysis of sediment samples taken from harbours. Substances measured were Cd, Hg, DDT and derivatives, PCBs, oil, Cu, Pb and Zn.
4. Fenitrothion and aminocarb were looked for in Mya arenaria, Mytilus edulis and Crassostrea virginica following aerial forest spray applications. Samples collected five days after spraying sometimes contained residues of fenitrothion but never of aminocarb.
5. A review of recent studies of the uptake and excretion of chlorinated and brominated hydrocarbons by fish was prepared. There are some differences between the behaviour of highly brominated and highly chlorinated compounds and the oxidation of isopropyl groups in Chloralkylene 12 (a potential PCB substitute) is a significant degradation route.
6. Fluoranthene and pyrene would interfere, if present in sufficiently high concentrations, with the quantitation of some tetra- and pentachlorobiphenyls..

7. Analysis of hepatopancreas and blood of lobsters, exposed to crude oil in the laboratory, were evaluated. Fluorescence emission was a good quantitative measure of oil contamination, provided that the latter could be confirmed by GCMS. Otherwise, creosote contamination may lead to erroneous conclusions. The best indicator of oil contamination appears to be the GCMS fingerprint of alkylbenzenes. Blood analysis was not a good indicator of oil contamination in this case.
8. Levels and distribution of contaminants - Mercury levels have been surveyed in water and fish from several lakes in Labrador. Notable levels have been found in lakes in the Labrador Through, a geologically rich area. None is believed to be of anthropogenic origin.
9. Crangon were analyzed for PCB accumulation from mud sediment spiked with mixed Aroclors 1242, 1254, and 1260. As in other species from this test, there was little accumulation from mud. Sandy sediments spiked at 1 ppm and mud sediments at 0.1 ppm wet weight contained measured concentrations of about 0.3 µg/gm dry weight.
10. Atlantic salmon eggs were analyzed for chlorinated hydrocarbons. The levels of DDE decreased considerably in comparison with those in 1971, DDD and DDT have not changed much. The concentration of PCB's (Aroclor 1254) is also lower, but still relatively high (2-6 µg/g lipid). Interestingly, the concentration of hexachlorobenzene may be increasing (approximately 0.04 and 0.14 µg/g lipid in 1971 and 1976, respectively).
11. Cis- and trans-chlordane and nonachlor were detected in lobster hepatopancreas, cod and white shark liver, Atlantic salmon eggs, and commercial fish oils as well as herring gull and double-crested cormorant eggs obtained between 1971 and 1977. Trans-nonachlor and cis-chlordane are the major isomers present. The levels are low relative to PCB and DDE and probably have not changed much since 1971.
12. Most of the present well-known environmental contaminants (e.g. PCB's, DDT, etc.) have the following properties: they are chemically resistant to either biological or non-biological degradation (hence they are persistent); they have appreciable vapour pressure at normal environmental temperatures (hence they are transported atmospherically and so are widely distributed); they are lipid soluble and so, when

accumulated by organisms, are sequestered in tissues of relatively low metabolic activity (hence are not exposed to degradative systems); they are produced industrially at the rate of several thousand tons/yr. Applying these criteria to other compounds, it was anticipated that diphenyl ether (a compound used widely in heat-transfer agents) would probably be an environmental contaminant. Using GC-MS techniques, its presence was confirmed in various sample types (water, fish, seals, and seabirds) from Nova Scotia.

13. Sixty cod of selected sizes were collected from the Gulf of St. Lawrence and analyzed for PCB's, HCB, Mirex, Hs, Pb, Cd, As, Se, Cu, and Zn to relate a variety of biological factors (length, weight, etc.) to contaminant levels. This study will be carried out for a number of years to document contaminant changes over the years. Additional samples of cod and redfish were analyzed from Flemish Cap.

#### POLLUTION DYNAMICS

1. Surface sediments from 20 stations on the Scotian Shelf, collected on a transect from Halifax to Emerald Bank and around Sable Island, have been analyzed for hydrocarbon content and composition by gas chromatography and fluorescence spectrophotometry. Some samples were taken near abandoned exploratory drilling sites in the Sable Island area. Hydrocarbons appear to be mainly derived from biogenic terrestrial sources as evidenced by an inverse correlation of concentrations with increasing distance from the mainland and a strong odd carbon preference in the n-alkanes. Contribution from petroleum sources, while minor, was most noticeable between Halifax and Emerald Bank. There is also evidence that the hydrocarbon composition at abandoned exploratory drilling sites has been slightly altered.
2. The dynamics of transfer of organochlorines are being studied within marine planktonic populations. Present information allows prediction of the amount of DDT one would expect in/on copepods and euphausiids for any given concentration of DDT in seawater. Both uptake and clearance of DDT in crustaceans are surface-area related phenomena which enabled to writing of a comprehensive formulation to encompass all crustaceans.

There is a further avenue for planktonic acculation of organochlorines through feeding. A number of feeding experiments have been run in which both the DDT retained by copepods following consumption of contaminated algal foods and that passed through in the feces were measured. Combining the

information we have learned about these two pathways, we can begin to construct a preliminary model of the organochlorine dynamics in the marine pelagic food web.

To test this model, we need to know the quantity of organochlorines in local phytoplankton, zooplankton and fish, seasonally. During 1977, plankton was collected bi-weekly in Georges Bay, N.S. and sieved into seven size categories (25, 63, 125, 250, 500, 1000 and 2000  $\mu$ m). Adult, juvenile forms and eggs of several of the commercially important pelagic fish (mackerel, herring smelt and gasperaux) were also collected. A suitable analytical method has been developed for this laboratory and samples are presently being analyzed.

3. The ARROW spill in February 1970 caused approximately one-half of the 600 km shoreline of Chedabucto Bay, N.S. to be heavily oiled with Bunker C fuel oil. An extensive field survey six years later identified only a few isolated areas where stranded oil, usually mixed with sediment to form a "pavement-like" material, remains. In a number of inter-tidal locations, oil was found mixed with sand and gravel up to several centimetres below the surface. Oil could not be detected in sub-littoral sediments in most areas of the Bay. It would be detected, however, in some inshore areas, and near Cerberus Rock, and is believed to originate from the erosion of stranded oil. Because most of the oil is heterogeneously mixed with sediment and some of the areas originally contaminated with ARROW Bunker C oil are now being further contaminated from other sources, a calculation of the exact amount of ARROW Bunker C oil remaining in Chedabucto Bay is impossible.

4. Suspended and sedimented particulate carbon, nitrogen, chlorophyll a and pheopigments were measured at various depths throughout the year in Bedford Basin, a small coastal marine bay. Seasonal and vertical differences in sedimentation rates were not simply related to changes in concentration of suspended particulate matter. Loss rates and settling velocities for measured variables were calculated to show that daily loss of carbon and nitrogen at various depths was always between 1 and 5% (0.1 to 2 m/day) of suspended material. Loss rates and settling velocities of plant pigments were an order of magnitude lower except following phytoplankton blooms during winter when algal cells settled directly. The measurements may be useful in predicting the residence time of dredged bottom material in the water column during dumping operations. They also quantify the daily loss through sedimentation expected for any organic or inorganic matter associated with settling particles.

5. Rates of oxygen uptake by algal and bacterial populations attached to sand, pebble, rock and detrital surfaces are directly related to surface area under constant conditions of temperature, pH and oxygen concentration. An inverse relation between respiration per unit organic matter and the organic content of attached communities on solid surfaces was also observed. Broad similarities in measures of community

metabolism on natural and artificial substrates support the idea that respiratory energy flow through algal and bacterial populations on solid surfaces is a conservative property of the intact community and is largely controlled by available space.

6. An international symposium on the recovery potential of cold water marine environments from oil spills was organized and held in October. Over 150 scientists from North America, Europe and Asia attended. The proceedings will be published in a special issue of the Journal of the Fisheries Research Board in the spring of 1978.
7. General studies of the levels, behaviour and dynamics of heavy metals (Hg, Zn, Cu, Pb, Co, Ni, Cr, V, Be) in the sediments of the St. Lawrence Estuary, Gulf of St. Lawrence and Saguenay fjord have been completed. The studies indicate that Zn is a contaminant and Cu and Pb are potential contaminants of the sediments in the upper St. Lawrence Estuary. Biogeochemically, mercury is a pollutant of the Saguenay fjord and lower St. Lawrence Estuary sediments. Zn and Pb are contaminants and V is a potential contaminant of the Saguenay fjord sediments, whereas Zn, Pb, V and Ni are potential contaminants of the lower Estuary sediments. Very little of the anthropogenic inputs of these metals have reached the open Gulf of St. Lawrence except from local sources in Chaleur Bay, Northumberland Strait(?) and the Bay of Islands, Newfoundland. Elsewhere the elemental concentrations are at or near natural levels.
8. Studies of the uptake of PCB's from spiked sediments (0.1 ug/g) are underway. Muddy and sandy sediments are used and the test animals are Nereis, Glycera, Mytilus, Mya, Crangon, and Homarus. The accumulation of PCB's occurs to a lesser extent from muddy than from sandy sediments.
9. Experiments to investigate the effect of body size of Nereis and Crangon and of PCB's concentrations in sediments, on the accumulation of PCB's by the animals, were completed. A number of live clams were exposed to PCB's in sea water to measure accumulation within the clams and to develop a method for spiking live clams for use in future work on uptake of PCB's by prey species. Animal and sediment samples have not been chemically analyzed to date.

10. An extensive re-examination of Chedabucto Bay, Nova Scotia sediments was carried out in the summer of 1976, for comparison with data obtained shortly after the major oil spill in 1970. Only two of the 79 sediment samples examined microbiologically had large numbers of hydrocarbon utilizing bacteria. The bulk of sediments were, with regard to bacterial populations, comparable to areas described as "clean" i.e. no apparent or known contamination with oil.
11. Recent studies have attempted to establish an optimal condition to facilitate depuration of biological contaminants from shellfish. Both an amphibian virus (LT-1) and E. coli have been employed as experimental contaminants. The highest uptake rate by oyster and soft shell clam was observed following 12 hours exposure to the contaminants, and the final concentration of the contaminant in the tissues of shellfish appears to depend on the concentration of the organism or virus in the contaminated water. Our preliminary results indicate that over 90% of the contaminants in the shellfish can be released within 24 hours after transfer to running sea water at 20C. However, the residual contaminants were not completely eliminated in our 96 hour experimental period. Factors affecting depuration rate such as salinity, temperature, feeding or not feeding, etc. for commercially important shellfish are being studied.
12. Precipitation samples from the four Atlantic Provinces were analyzed for mercury to determine the significance of aerial transport as a source.
13. Depuration - Measurements in vitro on aryl hydrocarbon-metabolizing enzymes in fish show that 2- to 5-ring compounds are readily metabolized. Induction of the enzymes by crude oil results in a 5- to 20-fold increase in the rate of metabolism of 4- and 5-ring compounds but has no affect on smaller aromatics. It is suspected that different cytochromes P-450 are involved in the metabolism of the two classes of hydrocarbons. In vivo depuration is currently being measured.
14. A study of trace metal distributions and behaviour in the estuarine regions of the Gulf of St. Lawrence has enabled the proportion of fluvially-derived metals, which are precipitated in the nearshore, to be estimated. The results also suggest that manganese released from nearshore pelitic sediments may make a significant contribution to manganese in pelagic sediments.



15. The distribution of stable carbon isotopes in total sedimentary organic matter in the estuaries and Gulf of St. Lawrence has confirmed that virtually all the terrigenous organic material entering the area is precipitated within the estuarine environment. The organic matter within the sediments of the Gulf of St. Lawrence is primarily of marine or local origin.
16. Measurements of organohalogen concentrations in nearshore marine sediments of the Canadian Atlantic Coast have been completed. The results indicate that the distributions of PCB's and DDT derivatives were more closely correlated with total organic carbon in the sediments than with sediment mineralogy.
17. During 1977 survey samples of water, suspended matter and sediment were collected from Baffin Bay, Davis Strait, Lancaster Sound, Jones Sound and Smith Sound. These samples will be used to elucidate the distributions of nutrients, trace metals, petroleum residues and particulate organic carbon, and to determine the nature and stability of particulate organic matter in the region. Results to date show that the concentrations of petroleum residues are generally less than 0.5 ug/l except in a few localities where natural hydrocarbon seepages are prevalent. The nutrient and oxygen isotope data are expected to assist in the identification of water flows through the Canadian Arctic Archipelago and, to a lesser extent, within the Arctic Ocean.

#### BIOLOGICAL EFFECTS

1. Sand shrimp (Crangon septemspinosus) and lead:-
  - a) A light and electron microscope study of the normal stages of spermiogenesis in the sand shrimp has been completed and submitted for publication. This study is being used as the standard against which changes in spermiogenesis in shrimp exposed to lead are compared.
  - b) In an initial experiment, shrimp were exposed to a range of concentrations of organic lead salts. A number of ultrastructural changes were noted: degeneration and swelling of mitochondria; thickening of testicular epithelium; extensive aggregation of membranes and mitochondria; and the formation of electron dense bodies arising from the degenerating ergastoplasm of the spermatocytes.
  - c) Shrimp exposed to lead died after moulting. The mortality rate was lower for female shrimps.
  - d) These experiments are continuing and ultrastructural changes in spermiogenesis of shrimp exposed to inorganic lead salts will be studied next.

2. Mummichogs (Fundulus heteroclitus) and brook trout (Salvelinus fontinalis) were exposed to 4, 15 and 38 ppm cadmium chloride levels in flow through tanks. At the light microscope level, kidney damage showed up in the proximal tubules of the mummichog. Hypertrophy and hyperplasia of gill epithelium was found in both species. An increase in hematocrit values occurred in both species after exposure to cadmium.
3. S. fontinalis were exposed to 3 ppm cadmium and tissues were fixed for electron microscopy. Initial results reveal epithelial lifting in fish exposed to cadmium at 6°C, while hyperplasia and edema were found in fish exposed to cadmium at 12°C. (A type of secretory cell found in the gills is being examined.) Other trout tissues will be examined for ultrastructural changes resulting from cadmium treatment.
4. A program has been started to determine the incidence of pseudo-branchial tumours in cod landed on the Atlantic Coast. To date an examination of 1009 cod landed at a Nova Scotian fish plant revealed the presence of only one bilateral pseudobranch tumour. Freshly caught cod will be looked at in the hope of obtaining fresh material for histological studies and cod landed at fish plants will be further examined to determine the frequency of this tumour.
5. Hagfish from the Bay of Fundy area have been examined for the presence of hepatomas such as reported by Falkmer in Sweden. Two population samples of 100 hagfish, each were examined but no hepatomas were found.
6. Flatfish landed at a Nova Scotian fish plant were examined for papillomas. A variety of parasites were encountered but no tumours. More extensive sampling will be carried out.
7. Fortuitously obtained tumour from regular sampling surveys (off Newfoundland) are being collected in anticipation of an international survey of the occurrence of neoplasias in marine organisms.
8. Work has continued on assessing the sublethal effects of known environmental contaminants. The index of sublethal effect studied has been the activity of the mixed function oxidase (MFO) system in fish; this is a group of enzymes which catalyzes the degradation of various foreign compounds, and the extent of its activity often reflects the history of exposure of fish to certain kinds of foreign compound. We found previously that DDT, and its principal metabolite in fish, DDE, did not induce activity of the MFO system. We have found since that PCB's, which are known environmental contaminants, will induce MFO activity in fish, as does 3-methylcholanthrene.



9. Oil spill dispersants have been shown to affect the heart rate of fish in a manner resembling anoxia or heavy-metal intoxication. The ranking of dispersants and surfactants is the same as the independently-obtained lethal toxicity. An external receptor on the gills is believed to be involved. The same agents also interfere with ciliary movement in bivalve gills.
10. Bivalves exposed to short-term (4 days) and long-term (6 years) oil pollution were assayed for aryl hydrocarbon hydroxylase and for N-demethylase activity. Short-term induction studies were carried out on Mya arenaria, Mytilus edulis and Ostrea edulis incubated in aqueous extracts of Kuwait crude oil or Bunker C (fuel) oil. For the chronic-induction studies, Mya arenaria and Mytilus edulis were collected from oiled clam beds (ARROW Bunker C) in Chedabucto Bay, Nova Scotia. None of the bivalves showed any basal or petroleum hydrocarbon induced aryl hydrocarbon hydroxylase or N-demethylase activity, as shown by their inability to metabolize benzopyrene or imipramine. In contrast, both oil-free control trout and trout taken from a polluted lake readily metabolized both these compounds. The inability of these bivalves to degrade petroleum aromatic hydrocarbons, and the tendency of these compounds to accumulate in the mollusc tissues, presents an opportunity for transfer of unaltered hydrocarbons into the foodchain.
11. Two populations of Mya arenaria, one from a chronically oiled lagoon (since the ARROW, 1970) and the other from a non-oiled lagoon, were compared as to population structure, growth and metabolism. The oiled lagoon sediments contained up to 3800 ug/gm oil (UV determination), and clams up to 200 ug/gm hydrocarbon in their tissues (fluorescence).

The oiled population differed from the non-oiled population in lower total numbers with fewer mature adults; a one to two year lag in tissue growth; a lower shell growth rate; and a reduced carbon flux with a lower assimilation rate.

Results are interpreted to indicate that the recovery potential of M. arenaria in these oiled sediments is low, and that these oiled populations remain under continued stress six years after the ARROW spill.
12. The alga Chlamydomonas reinhardtii was cultured phototrophically for three weeks on oil impregnated agar medium. The oils used included Kuwait Crude, Saran Gach Crude, Diesel 25 and Bunker C fuel oil. No evidence for an enhanced level of mutation to streptomycin resistance was detected after any of these oil exposures. Furthermore, prior growth on the oiled media did not reduce plating efficiency and no small-colony (slow-growth) mutants were detected.

13. The interactions between the polychaete Arenicola marina, contaminated with the fresh API reference oils and weathered Bunker C oil remaining from the 1970 ARROW spill, were investigated in laboratory experiments. Worms can tolerate low concentrations of sediment-bound oil, although the sediment working rate is reduced depending upon oil type, concentration, and the degree of weathering. Hydrocarbon concentrations, measured gravimetrically and by gas chromatography and fluorescence spectroscopy, were substantially lower (17-72%) in worm casts than in initial sediment. This loss can be accounted for by microbial degradation, which is stimulated by the worms' activity, uptake of hydrocarbons into worms, and perhaps dissolution. A large population (10-25/m<sup>2</sup>) of Arenicola is present at Black Duck Cove, N.S., living in sediment contaminated with weathered Bunker C oil remaining from the ARROW spill. These worms, which have spent their entire lives in oil-polluted sediments, do not have markedly elevated hydrocarbon concentrations and behaved no differently in experiments than worms collected from a clean environment. Calculations suggest that they are capable of removing the oil present in a square meter of sediment in 2-4 y. After any oil spill, when concentrations reach tolerable levels, it appears that activities of deposit feeding animals such as Arenicola, can accelerate the weathering rate of sediment-bound oil.
14. Caudal muscle and ovarian tissues from Striped bass (Roccus saxatilis) from the Annapolis Rivers (unsuccessful reproduction) had average levels of 0.89 µgHg/g wet weight (0.033 µgPCB/g), muscle levels and 0.14 µgHg/g (1.42 µgPCB/g) ovary levels. Striped bass from the Subenacadie River (successful spawning) had average muscle levels of 0.51 µgHg/g (0.01 µgPCB/g). Ovarian levels averaged 0.06 µgHg/g (0.05 µgPCB/g). Both mercury and PCB contents increased with size (length gave the best relationship). The smaller size and reduced maturity of Shubenacadie River fish relative to Annapolis River fish, helps explain the observed differences in mercury, PCB and tissue lipid levels found in the two stocks. The difference in organochloride content of the ovaries deriving from age and size structure of the stocks may explain the successful reproduction of striped bass in the Shubenacadie River but not in the Annapolis River.
15. Nominal 96 hr.-LC50 values of several chlorinated compounds for Crangon at 20 C were determined to investigate what would be permissible concentrations under the Ocean Dumping Control Act. Chemical analysis of the test solutions have been completed and the data re-analyzed using average measured concentrations. The 96 hr.-LC50's in mg/l, based on measured concentrations, are hexachlorobenzene >5, Aroclor 1254 0.085, Aroclor 1242 0.030, chlordane 0.002, dieldrin and DDT 0.001, endosulfan and endrin 0.0004. Tests at 10 C with four of the above compounds indicated that the lower temperature caused no change in the 96 hr.-LC50.

16. Measurements of lethality of permethrin and three other pyrethroids to adult lobsters were completed enabling comparison with similar data for juvenile salmon and comparison of structural-activity relationships for the freshwater and marine species.
17. The lethality of creosote to Homarus occurs 5-10 mg/l for adults and about 0.05 mg/l for larvae. The threshold for Crangon is 0.1-0.25 mg/l.
18. The behaviour of herring in the presence of a sulfite pulp mill effluent and humic acid was studied. The fish avoided the effluent in concentrations above 2-3 mg/l (as sodium ligno-sulfonate). Model experiments indicate that the fish avoid ligno-sulfonates and humic acid rather than some more toxic compounds of the effluent.
19. The toxicities of sandy sediments spiked with each of the 8 compounds to Crangon at 10 C are being tested for comparison with their toxicities in sea water. Minimal amounts of sea water were added to force the Crangons to remain in contact with the sediment. The series of testing and chemical analysis of the test sediments are not completed.
20. A synergistic effect of phosphamidon and methidathion (Supracide) was obtained in toxicity tests with Homarus. It appears that phosphamidon inhibits the detoxification of methidathion.
21. A program was initiated to investigate possible effects of fine suspended solids in the sea. Laboratory behavioural tests with herring show that schooling fish avoid approximately 25 mg/l (median particle diameter = 40  $\mu$ ). Sediment treated with 1 ppmPCB (wet weight basis) was avoided at approximately the same threshold, indicating no effect of absorbed PCB on this response.
22. Structure-lethality (juvenile Atlantic salmon) relationships for aromatic compounds were expanded. There appears to be 3 groups of compounds:
  1. Benzenes containing sulfo groups, practically nonlethal (LC 100>mg/l).
  2. Benzenes containing carboxyls regardless of other groups; one hydroxy or one amino group. Lethal threshold (LC mole/l)

related to octanol/water partition coefficient (P):  
 $\log (1/LC) = 0.26 \log P + 3.13$  (LC 1-100 mg/l).

3. Di- or more substituted benzenes and substituted naphthalenes:  
 $\log (a/LC) = 0.27 \log P + 4.34$  (LC  $\leq$  1 mg/l).

23. Ecological effects of Sulfide Waste Liquor in the L'Etang Inlet include local extinctions of eukaryotic organisms. Repopulation by opportunistic anoxia-tolerant species occurred. Most of the benthic production in the anoxic zone is probably lost to higher links of the food web. An estimate of the magnitude of this loss is made, based on data obtained before the mill became operational, inclusive of standing crop production.

Field observations in Lower L'Etang suggest that sulfide release from sediments is tidally controlled. LW release of sulfides is suggested by the high levels in bottom water, and at HW, pressure may prevent its release. This phenomena will be investigated in summer of 1977.

24. A sensitive RIA method has been developed to be used to measure quickly and accurately the principal adrenocorticosteroid in most (teleost) fish. This will be of use in determining blood hormone levels which can be used as an early warning of stress caused by pollutants and other factors.

25. Work has been carried out to improve the sensitivity of our autoradiography method for determining steroid hormone levels of fish under stress. In addition, the use of high pressure liquid chromatography in determining steroid hormone levels is being investigated by using a more sensitive "X-ray" plate.

26. An experiment has been in progress for several months where groups of cod are being fed different levels of PCB's to determine the tissue uptake of the PCB's as well as the effects of the various levels of the PCB's on the biochemistry of the cod in the areas of egg fertility, sex hormones and gonadal and egg enzymes.

27. Used crankcase oil has been found to contain a powerful mutagen. The active material is more polar than normal polycyclic hydrocarbons and requires metabolic activation in the Ames test. Its Ames-test properties include it in the "positive frame-shift" class of mutagens, meaning that it is probably a carcinogen. Unused motor oil and other crude and refined oils do not show significant mutagenic activity. Waste crankcase oils are virtually uncontrolled, but estimates suggest it is one of the most significant hydrocarbon inputs to aquatic systems.

28. The aryl hydroxylase of cunner can be induced by feeding on mussels which have themselves been exposed to oil and partially depurated.

29. Experiments were carried out on the in vitro effects of cadmium (at levels between 0.1 and 1.0  $\mu$  mole/3ml) on the relative activities of malate (MDH), lactate (LDH), glutamate (GLDH), isocitrate (ICDH) dehydrogenases, and aspartate (ASAT) and alanine (ALAT) aminotransferases, in the mitochondria and in the cytosol of cod (Gadus morrhua), and rabbit (Oryctolagus cuniculus).

Cadmium enhanced the relative activity of the mitochondrial MDH of cod and rabbit, possibly because of an allosteric effect on the enzyme, although it depressed the relative activity of the cytosol MDH in these animals.

The relative activities of the cytosol LDH of cod, the mitochondrial and cytosol GLDH of cod and rabbit, the cytosol ASAT of cod, and the mitochondrial and cytosol ASAT of rabbit were not significantly affected by the cadmium levels studied. On the other hand, the relative activities of all other enzymes were depressed by the presence of cadmium, although they differed among themselves in their sensitivity to the heavy metal. Of particular interest is the enzyme ALAT, the activity of which was completely obliterated in the mitochondria and cytosol of cod and in the cytosol of rabbit in the presence of 1  $\mu$  mole cadmium/3 ml.

Denmark

(A Nielsen)

Investigation of the productivity and carbon cycle of an area in the Northern Sound as well as studies on dynamics and growth of benthic animals are carried out by the Marine Biological Laboratory, University of Copenhagen.

Studies on microbial element cycling in marine sediments in particular nitrogen and sulphur are carried out by the Institute of Ecology and Genetics, University of Aarhus.

Studies on uptake and effects of sublethal concentrations of environmental poisons in marine animals are carried out by the Institute of Biology, University of Odense.

The investigations of the exchange of water and material through the Danish Straits have been continued (Agency of Environmental Protection).

Greenland

(P Johansen)

Studies on the impact of tailings disposal to the sea from a lead-zinc mine and mill in West Greenland continued. Some of the solid deposited tailings seem to dissolve and cause a rather widespread pollution with dissolved zinc, lead and cadmium. Bioaccumulation of heavy metals has been demonstrated in the liver from some fish species in the area at the disposal site and in intertidal seaweed and mussels.

Baseline studies related to exploratory drilling for oil off west Greenland continued, i.e. studies on the benthos, microbial degradation of oil and hydrocarbon levels in marine organisms and sediments.

A study of the fate and effect of the 390 tons bunker oil spill in the Melville Bay (c. 75°N - 61°W) in August 1977 was carried out. The study included sea water (analysis for hydrocarbons), zooplankton (distribution and uptake of oil), micro-organisms (oil degradation), seals and birds.

Finland

(P Tulkki)

During 1977, data on the open sea were collected from all sub-areas of the Baltic Sea and a statistical study on the levels and trends of different parameters describing the quality of the water in the Gulf of Bothnia was made.

A model study on oxygen and the carbon balance was continued.

The occurrence of heavy metals and organochlorine compounds in bottom animals, sediments and sea water was studied both in the open sea areas and near-coast localities in the Gulf of Finland and the Gulf of Bothnia. Some of these studies were made according to recommendations by ICES and the ICES/SCOR Working Group.



Studies of the plutonium content of Baltic Sea sediments were made to determine the level of this substance and to use it as a means of dating sediments.

Methodological investigations were performed to develop the determination of metals (Fe, Mn, Cu, Zn) and nutrients (P, N) in sea water and the intercalibration of respective methods.

Bilateral co-operation between Finland and the USSR and Finland and Sweden continued. This activity consists of coordination of research activities, symposia, meetings, intercalibration and exchange of hydrographical, chemical and biological data useful in evaluating the state of pollution.

Finnish scientists actively participated in all fields of the scientific-technological work carried out by the Interim Commission of the Helsinki Convention.

Mineral oil content of Sea water in the Gulf of Bothnia and in the Gulf of Finland was determined. The content was 2.4 to 8.1  $\mu\text{g}$  per liter in the open sea area.

Monitoring of the sea areas around Finland has taken place at the fixed stations in co-operation with the water authorities and the Institute of Marine Research. In addition, the water authorities, National Board of Waters, and its district organizations have made intensive monitoring in the near-coast localities off pollution sources. These include special studies on certain pollutants (heavy metals, oils, toxic substances).

The pollution load from land-based sources has been evaluated for the Bay of Bothnia in co-operation with Swedish scientists.

In the Archipelago Sea a long-term field study of currents and transport of pollutants was completed and a report is in preparation. This relatively extensive survey has been carried out by water authorities, scientific institutions, communities, industry and community planners.

The National Board of Waters has continued the registration of the pollution load coming from different industries and purification plants of communities. Yearly discharges to the Baltic Sea were reported.

France

(Cl Alzieu)

I - PROGRAMMES DE SURVEILLANCE

- Le Réseau National d'Observation de la qualité des eaux marines (R N O) a été étendu en 1977 à 17 points d'appui dont trois zones conchyliques supplémentaires. Simultanément de nouveaux paramètres ont été mesurés : silicates, chlorophylles, métaux lourds sur eau non filtrée et comptages de particules. Les laboratoires participant au R N O ont continué au cours de l'année le programme d'intercalibration des méthodes d'analyses par un échange de solutions étalons de sels nutritifs, métaux lourds et composés organochlorés dans l'eau.

- Des régions présentant un intérêt particulier ont fait l'objet d'études visant à suivre l'influence des rejets industriels sur la qualité du milieu.

- La surveillance de la contamination de la faune marine par les micropolluants rémanents a été poursuivie et complétée par des dosages de métaux lourds dans les thons et roussettes de Méditerranée et des composés organochlorés dans différents organes des cétacés échoués sur nos côtes.

- Sur le plan international, la France a participé pour la deuxième année consécutive au plan bleu pour la Méditerranée sous l'égide du Programme des Nations Unies pour l'Environnement (PNUE). Les travaux ont été consacrés à l'étude de la contamination de la faune par les métaux lourds et les composés organochlorés ainsi qu'à l'effet des polluants sur les biocénoses. Ces programmes étaient coordonnés par la FAO/CGPM.

- Dans le cadre d'un groupe de travail chargé de l'application de la Convention de Paris, une étude en commun de surveillance de la Manche a été mise en place conjointement avec les responsables du Royaume-Uni. Les résultats seront communiqués au Joint Monitoring Group lors de sa prochaine session.



## II - ETUDES ET RECHERCHES

### Pollutions thermiques

Les études lancées en 1976 dans le cadre des projets d'implantation de centrales nucléaires sur le littoral se sont intensifiées, tant du point de vue études sur le terrain que des expérimentations en laboratoire. Les premiers résultats de l'étude sur simulateur des effets biologiques sur le phytoplancton et les larves de crevettes dus à des variations brutales ou cycliques de température et à l'addition de chlore, ont déjà été exploités.

### Pollutions par les métaux lourds

Les relations existant entre les teneurs en Hg et méthyl-Hg, et d'autres métaux ont été étudiées sur les thons rouges de Méditerranée.

### Pollutions pétrolières

Les différents laboratoires étudiant la toxicité et la biodégradation des produits destinés à la lutte contre les pollutions pétrolières ont poursuivi l'harmonisation des méthodes et ont procédé à des tests comparatifs sur différents produits commerciaux.

Les opérations de surveillance par télédétection des déballastages clandestins des pétroliers ont été renforcées.

### Poissons nécrosés

Une étude épidémiologique et anatomopathologique de nécroses observées sur certains poissons plats pêchés en Manche a été engagée dans le courant de l'année. Des travaux de laboratoire préciseront l'influence de certains polluants ou microorganismes dans le développement des nécroses.

Federal Republic of Germany

(V Dethlefsen)

POLLUTION

Monitoring

Seawater

The monitoring programme which has been started in 1975 was continued in 1977. Analysis of seawater samples, sediments and/or particulate matter from 35 stations in the German Bight for heavy metals and organohalogen compounds were carried out. In the western Baltic Sea seawater was analysed from 8 stations and sediments were analysed from 28 stations. Also radioactivity of surface water of the German Bight and the western Baltic Sea was continuously recorded by automatic sampling stations (Deutsches Hydrographisches Institut, Hamburg).

A variety of institutes carried out investigations on the concentration of pollutants in seawater for research purposes (Biologische Anstalt Helgoland; Institut für Meereskunde, Universität Kiel; Institut für Meeresforschung, Bremerhaven).

Organisms

Monitoring of levels of heavy metals, hydrocarbons, and chlorinated hydrocarbons in marine organisms in the German Bight and the western Baltic Sea was continued (Staatliche Veterinäruntersuchungsämter, Cuxhaven und Bremerhaven; Institut für Küsten- und Binnenfischerei, Hamburg; Isotopenlabor der Bundesforschungsanstalt für Fischerei, Hamburg; Institut für Meereskunde, Universität Kiel; Institut für Meeresforschung, Bremerhaven; Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg).

Marine Chemistry

Investigations of concentrations of heavy metals, pesticide type hydrocarbons, PCBs, and petroleum in the water layers at different depths on a leg Hamburg-Shetland Islands and during BOSEX 77, were carried out. Investigations were also carried out on the effects of residues of incineration of organochlorine compounds in seawater, on the development of sampling devices for seawater for subsequent analysis of organochlorines, neutron activation analysis was applied to the measurement of noxious trace elements in seawater, the formation of acute lack of oxygen in the western Baltic Sea, on the development of methods for analysis of radio isotopes in seawater, on remote sensing of pollution by airplane in the German Bight, on the transport of particulate matter in the North Sea, on remote sensing of mass concentrations of blue green algae in the western Baltic and their influence on phosphorous and nitrogen budget (Deutsches Hydrographisches Institut, Hamburg), on organohalogen compounds in sediments (Institut für Meeresforschung, Bremerhaven).

The Baltic Intercalibration Workshop in Kiel showed considerable discrepancies in the analysis of heavy metals in seawater. Heavy metals in the water

column were also studied during 3 surveys in Kiel Bight and during BOSEX. Earlier data of BALTIC '75 were finally analysed. Organochloric pesticides and PCBs were measured in samples collected in sediment traps in Kiel Bight in 1975 - 1977 and during BOSEX. A special sampling apparatus was developed which permits the fluid-solid extraction of dissolved organic compounds and heavy metals in large amounts of sea-water pumped from all depths down to 150 m. (Institut für Meereskunde, Kiel).

#### Investigations on the Effects of Pollutants on Marine Organisms

##### In situ Studies

In situ studies were carried out on the effects of sewage dumping and dumping of wastes of Titaniumdioxid-industry on water quality, structures of benthic communities and fish-populations (Institut für Meeresforschung, Bremerhaven; Institut für Küsten- und Binnenfischerei, Hamburg; Deutsches Hydrographisches Institut, Hamburg), on diseases of marine fishes in coastal waters, in order to find a correlation between coastal pollution and the incidence of ulcers (Institut für Küsten- und Binnenfischerei, Hamburg; Institut für Meereskunde, Universität Kiel), on the effects of sewage dumping on benthic communities, on the effects of crude oil on selected organisms in the sandy intertidal area of the mesohaline region of the Elbe estuary (Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg).

##### Laboratory Investigations

##### Heavy metals

Investigations were conducted on the release of heavy metals from sediments (Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg), on the effects of lead on bacteria in sediment and seawater in long term constant flow cultures, on the toxicity and accumulation of lead and cadmium by isolated marine bacteria (Institut für Meeresforschung, Bremerhaven), on the influence of Zn on the growth of marine plankton algae (Scippsiella faeroousae, Prorocentrum micans, Gymnodinium splendens, schröderella schöderi, Talassiosira robula, on the toxicity of cadmium of Phaeodactylum tricornutum, Dunaliella marina and Isochrysis galbana (Institut für Meeresforschung, Bremerhaven), on the effects of cadmium on the growth of Laminaria saccharina in constant flow experiments (Biologische Anstalt Helgoland), on synergistic effects of heavy metals on exploited populations of Harpacticides (Tisbe holothuriae), on the effects of ATP-metabolism of Crangon crangon (Biologische Anstalt Helgoland), on the accumulation of cadmium by Crangon crangon in constant flow experiments (Institut für Küsten- und Binnenfischerei, Hamburg), on the effects of heavy metals on the reproduction of benthic polychaetes (Ophriotrocha, Dinophylus) (Biologische Anstalt Helgoland), on the accumulation of lead and antimon by Mytilus edulis (Institut für Meeresforschung, Bremerhaven), on the accumulation arsenic by Mytilus edulis (Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg), on sublethal long-term effects of cadmium on young stages of Pleuronectes platessa, Limanda limanda and Platichthys flesus in constant flow experiments (Institut für Küsten- und Binnenfischerei, Hamburg; Biologische Anstalt Helgoland), on the effects of cadmium, lead and mercury on the physiology

and different blood parameters of eels (Anguilla anguilla) (Institut für Küsten- und Binnenfischerei, Hamburg), on the effects of sediments, on accumulation of heavy metals by Mytilus edulis and Lanice spec. (Institut für Meeresforschung, Bremerhaven), on the toxicity of cadmium on the early developmental stages of Mytilus and on hydroids under different environmental conditions, on the importance of organo-complexes on the toxicity of heavy metals in macrophytes and on the pathways of accumulation and retention time in fish, Mytilus and Crustacea (Institut für Meereskunde, Kiel).

#### Chlorinated hydrocarbons

Investigations were conducted on the effects, accumulation and loss of lindane, gamma HCH, pentachlorophenol on annelides, alpha HCH, gamma HCH, heptachlorepoxyd, DDD, Dieldrin, and alpha endosulfan with Mytilus edulis; on the bacterial degradation of organohalogen compounds (Institut für Meeresforschung, Bremerhaven), on the uptake and transfer of lindane in laboratory freshwater and marine food chains in constant flow experiments (Institut für Hydrobiologie und Fischereiwissenschaften, Hamburg).

#### Fossile hydrocarbons

Investigations on the effects of 14-C-labelled hydrocarbons on early life stages of marine fishes were continued (Institut für Meereskunde, Kiel). The influence of fuel-oil on feeding behaviour of Crangon crangon and fish larvae is investigated (Institut für Meeresforschung, Bremerhaven, Institut für Meereskunde, Kiel).

#### Other pollutants

Combined effects of emulsifiers and detergents together with heavy metals on flounder, plaice and Crangon crangon are investigated (Institut für Küsten- und Binnenfischerei, Hamburg; Biologische Anstalt Helgoland). Studies were carried out on the evaluation of river pollution (Institut für Hydrobiologie und Fischereiwissenschaft, Hamburg; Institut für Meeresforschung, Bremerhaven) and on the development of bioassays using bacteria and larvae of oysters (Institut für Meeresforschung, Bremerhaven). Transplantation experiments with Mytilus edulis were conducted in order to measure tissue residues before and after transplantation to different locations (Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg).

#### Iceland

(J Ólafsson)

Work was continued on the input of disposal of untreated sewage from coastal sewers at the inner part of Faxa Bay. Aspects of the analytical procedures in the determinations of heavy metals (Fe, Mn, Zn, Cr) were under review.



Ireland

(Dr D O'Sullivan and Dr M M Parker)

A. Department of Fisheries, Aquatic Environment Unit

1. Fish and Shellfish Quality Monitoring

Monitoring of the levels of six heavy metals in six species of fish and two species of commercial molluscs on a nationwide basis continues. Fish samples are taken at ports of landing in the course of other routine studies while the molluscs are collected from commercial beds.

2. Estuarine Water Quality Surveys

Five estuaries or bays on the south and west coasts have been examined. Hydrographic parameters, primary productivity, and organic loadings have been assessed, together with heavy metal levels in sediments, seaweeds and shellfish.

3. Surveys of offshore dumping sites

Owing to mechanical problems, it was not possible this year to carry out a survey of the site off the south coast on which an industrial waste dumping occurs. A preliminary survey of the east coast sewage sludge dumping site was carried out.

4. Biological Studies

A baseline study in Killala Bay on the west coast was completed. This involved surveys of the rocky littoral and the soft sub-littoral and a study on the movements of salmon within the bay in relation to the position of a new industrial outfall.

5. Sand and Gravel

No extraction occurred during 1977.

B. Other Research

1. Carnsore Base line Survey

At the instigation of the Electricity Supply Board, a baseline survey is being carried out in the region of Carnsore Point, which has been chosen as a potential site for a nuclear power station. A team from University College, Dublin (Department of Zoology) are engaged in quantitative surveys of the rocky and sandy littoral, and of inshore plankton and young fish; concurrently, studies of records of commercial and game fish and shellfish from this area are being carried out. University College, Galway (Zoology Department) is engaged on a survey of the offshore soft benthos and University College, Cork (Botany Department) has carried out a survey of littoral macro-algae.

## 2. Dublin Bay Study

A multi-disciplinary team from Trinity College, Dublin, are carrying out research in Dublin Bay and elsewhere on the East Coast, on the effects of pollutants, particularly heavy metals and nutrients, on the organisms and sediments, with the aim of developing criteria for the assessment of environmental quality in estuaries.

## 3. Cork Harbour Project

Teams from the Zoology and Botany Departments, University College, Cork, are undertaking surveys of the benthic fauna and the benthic and littoral flora, in relation to pollution parameters in this industrialised estuary.

### Netherlands

(S J de Groot and J Duinker)

#### Work carried out by the Netherlands Institute for Fishery Investigations

Pollution by organochlorine compounds - PCB, dieldrin and DDT - remained as in previous years the major environmental problem for the Dutch fisheries.

The organochlorine compounds in eel from various inland water localities were determined. A noticeable influence of river Rhine water on the contents of PCB and pesticides was found.

PCB studies in 1977 showed that levels for herring, sprat and mackerel from the southern North Sea were more or less constant and comparable with data found in literature.

In order to get an insight in the amount of industrial pollution by chlorinated hydrocarbons the studies in the western Scheldt estuary were continued and HCB, other pesticides, and PCBs were analysed in mussels (Mytilus edulis) sampled June 1976 from different areas of the Scheldt estuary. Compared with 1975 a decrease of all chlorinated hydrocarbons was recorded. The distribution patterns of HCB, PCBs, total DDT, and dieldrin were determined. The Sloe area and Terneuzen appear to influence the content of PCBs. Such conclusion for HCB and the other pesticides is not justified.

In the framework of the ICES Working Group on Pollution baseline and monitoring studies in the Oslo Commission and ICNAF areas PCB values were determined in cod and hake livers. In 1974/75 and in 1976/77 the cod was caught on three different sampling places of the North Sea. In 1974/75 the hake was sampled in the Bay of Biscay and in 1976/77 in the Atlantic Ocean west of Ireland. The southern part of the North Sea was the most contaminated area, where on a fat base the PCB concentration was 39 ppm in 1974/75 and 48 ppm in 1976/77. The lowest concentrations of polychlorinated biphenyls were found in the northern North Sea and the Atlantic Ocean (5-8 ppm on a fat base). On a product base only the livers of the northern North Sea and the Atlantic Ocean are below the American norm of 5 ppm PCB on a product base. The PCB concentrations in other fish products from the North Sea are amply below 5 ppm and problems for the consumer are not to be expected.

A method is at present developed to determine kepone, and it is likely that next year the first results can be reported here. The same applies for a method developed to study the bio-degradation of organohalogen compounds.

Work carried out by the  
Netherlands Institute of Sea Research

The investigation of the role of estuaries in retaining dissolved and particulate trace metals was continued.

Water and suspended matter was sampled in different salinity regimes of the major rivers entering the North Sea from the Federal Republic of Germany, the Netherlands, Denmark and the adjacent coastal regions. The samples were analysed for trace metals and chlorinated hydrocarbons.

### General

Initiated by the Director-General of the Ministry of Public Works and Transport in mid-1977, a national committee was founded to study the effects of marine sand dredging in the Dutch Waddensea. Two Working Groups should carry out more detailed investigations. Working Group I deals with the sediment transport and also the process and the time needed for the back-fill of sand pits, as well as the technical and financial aspects of marine sand dredging. Working Group II deals e.g. with the regeneration of sand and silt layers, the bottom fauna and flora, and in general the influences of dredging upon the water quality and the bottom communities in particular. The committee is aiming for a final report in mid-1979.

### Norway

(K H Palmork)

### Pollution

#### 1. Field Programmes

1.1 Investigations on the environmental qualities in the Skagerak from Risør to Grimstad. Measurements were made of temperature salinity, oxygen and nutrients. (Biological Station Flødevigen). 10 surveys were performed throughout the year. Continued study in south-eastern Norway. A programme covering baseline studies of fish and shellfish productivity in the Oslofjord and adjacent coastal waters is planned to cover a 5 years period ending in 1978. Seven cruises spread over the entire year were completed in 1977. Primary production, phytoplankton, zooplankton, fish larvae and the distribution of fish and shellfish were analysed (Biological Station Flødevigen).

1.2 Investigations of the environmental qualities of selected Norwegian fjords from Oslofjord to Varangerfjord were carried out in November-December. The fjords were selected to represent different types of environmental conditions, fjords with expected industrial loads, domestic

loads or no expected loads. Measurements were made of salinity, temperature, primary production indices, nutrients and oxygen distribution, turbidity and particulate matter (Institute of Marine Research).

1.3 Studies including a very large number of analyses of the content of heavy metals (Fe, Cu, Zn, Cd, Hg, Pb) in the flesh, liver and gonads of flounders (Platichthys flesus) from various localities in the Oslofjord and in some of the flounders' food organisms were completed and the results presented in a Cand. real. degree thesis. (Institute for Marine Biology and Limnology, University of Oslo).

1.4 During 1977, 207 samples of various fish and 27 catches of sprat were collected from the Greenland fjords, Norway N-5 and analysed for the content of metals and chlorinated hydrocarbons. The concentrations of mercury, lead, copper, cadmium, arsenic, and chlorinated benzenes, styrenes and biphenyls were determined in fish filets, liver and whole fish (sprat). It was found that the concentration of chlorinated benzenes and styrenes in whole sprat increased with age (0-3 years). (Directorate of Fisheries' Central Laboratory, Vitamin Institute and Institute of Marine Research).

1.5 Environmental conditions in coastal sea water. This programme continued for the fourth season. The organic load of the Baltic Current is being investigated from the Øresund, through the Kattegat, Skagerak and along the western Norwegian coast. Continuous measurements are made of particulate matter, organic components, nutrients and temperature, while primary production indices are measured at regular intervals (Institute of Marine Research).

1.6. Investigations of oil pollution in Norwegian waters by analysis of selected aromatic and sulfuraromatic hydrocarbons and also determination of total hydrocarbon content in cases of heavy pollution. The following projects have been operated. Monitoring of the North Sea on a section between Fedje and Shetland 5 times, 4 stations each time. Monitoring of Fensfjorden, recipient of waste water from a petroleum refinery, 5 times, 4 stations each time. Petroleum hydrocarbons in benthic organisms from coastal areas in south-western Norway polluted by Iranian crude oil. Survey of the North Sea, especially the central areas, during and after the Ekofisk-Bravo blowout for petroleum hydrocarbons in water and biota (Institute of Marine Research).

1.7 Investigations following the Ekofisk Bravo blow-out. These included studies of the physical environment and drift of oil, determination of petroleum hydrocarbons in the water column, fate of the floating oil and occurrence and distribution of particulate oil. Oil-degrading bacteria and fungi were studied and microbial counts undertaken. Phytoplankton and primary production was investigated as were effects on net- and nanoplankton, zooplankton, fish eggs and larvae. Observations were also made of fish. (Institute of Marine Research and other Norwegian Institutions).

1.8 Monitoring of pollutant hydrocarbons in a littoral community. The structure of boreal hard rock littoral communities seems to be governed largely by the success or failure of a few key species, and this environment may be especially vulnerable to the effects of pollutants. An attempt to link population fluctuations of such species to tissue hydrocarbon levels, is made in a study of population dynamics, seasonal fluctuations in lipid content, and composition and concentrations of hydrocarbons in tissues in



in four key invertebrate species on a hard rock littoral site in the south west Norway. (Institute of Marine Biology, University of Bergen).

1.9 Monitoring of the pelagic tar concentrations in the waters off the Norwegian coast from Skagerak to the Barents Sea. The project is a contribution to IGOS Pilot Project on Marine Pollution (Petroleum) Monitoring under GIPME, Global Investigation of Pollution in the Marine Environment. (Institute of Marine Research).

1.10 Determination of bacterial numbers in the Ekofisk area of the North Sea after the Bravo accident (Dept. of General Microbiology, University of Bergen).

1.11 Measurement of bacterial numbers by several methods, measurement of oxygen consumption and nutrient uptake by heterotrophic bacterial populations of a fairly polluted fjord (Grimstadfjorden) near Bergen. Assessment of oil degradation. (Dept. of General Microbiology, University of Bergen).

1.12 Heavy metals in fish and shellfish. Stocks of commercial fish are continuously being analysed for mercury, cadmium, zinc, copper and lead at the official Norwegian Quality Control Institute for Canned Fish Products. Involved in this monitoring is also the Vitamin Institute of the Directorate of Fisheries. These results are made available to the Institute of Marine Research, and selected adequate observations are included in the Norwegian contribution to the ICES conjoint monitoring of fish and shellfish in the North Sea. (Institute of Marine Research).

1.13 Monitoring of pesticides and PCBs in cod and capelin has been carried out in Norwegian waters as part of the ICES monitoring programme (Institute of Marine Research).

1.14 The Norwegian Institute of Water Research, NIVA, has been assigned by several industries and municipal authorities in discharge problems of different water systems including fjords. NIVA is further conducting baseline studies of heavy metals and studying potential growth in natural and polluted aquatic systems, also fjords. (The Norwegian Institute of Water Research, Oslo).

1.15 Monitoring has been carried out at pilot projects within the scope of a national monitoring programme in preparation. (The Norwegian Institute of Water Research).

## 2. Laboratory Assays

2.1 Specific biological programmes related to thermal effects were carried out and mortality, growth, hatching success and temperature preferences were studied on commercially important fish and shellfish species. (Biological Station Flødevigen).

Behaviour of cod and sprat below crude oil in the surface was studied in aquarium (Biological station Flødevigen). Effects of petroleum hydrocarbons on hatching, growth and mortality of fish larvae and zooplankton were studied in different experiments (Biological Station Flødevigen).

2.2 Oil pollution and larvae. The influence of crude oil, oil products and oil dispersant is studied using larvae of sea urchins and fishes as test objects. Effects on the fertilization process, cleavage rate and mode of differentiation are registered and combined with studies at the ultrastructural level (Institute of Biology and Geology, University of Tromsø).

2.3 Oil pollution and plankton. The influence of crude oil and oil dispersants on holoplanktonic organisms, especially Copepoda, is tested. (Institute of Biology and Geology, University of Tromsø).

2.4 Investigations on dissolving and degradation of selected aromatic and sulfur-aromatic hydrocarbons in an outdoor tank polluted by Ekofisk crude oil. Organoleptic and chemical analysis of saithe from aquaria with polluted water. Intercalibration of samples of polluted water, mussels and sediment between three Norwegian laboratories involved in oil pollution studies (Institute of Marine Research, Continental Shelf Institute and Central Institute for industrial research).

2.5 Fate and effects of oil hydrocarbons in a shallow water sandy area. Marine sediments may act as sinks for oil hydrocarbons, and organisms living in shallow water sediments may encounter hydrocarbon levels which are higher than those of the water above, and which reflect the inputs over a long time. A study of accumulation and biotransformation of oil hydrocarbons in a natural benthic environment, and the effects on the existing organisms, is made in a long time experiment, in which oil hydrocarbons are periodically introduced to the water above an artificially enclosed sandy bottom at 8 m depth. (Institute of Marine Biology, University of Bergen).

2.6 Effects of toluene on the isopod Cirolana borealis. Pollutant stress in organisms is reflected on all biological levels of organization, and several stress indices have been proposed. In laboratory experiments, in which the marine isopod Cirolana borealis has been exposed to toluene, an important aromatic hydrocarbon in oil, the sensitivity of some properties of the adenylate system towards pollutant stress have been investigated. The results have been submitted for publication. (Institute of Marine Biology, University of Bergen).

2.7 Development of a direct method for measuring oil degradation rates by microorganisms. Determination of aldehydes and ketones as primary products of bacterial oil degradation. (Dept. of General Microbiology, University of Bergen).

2.8 The effects of interacting heavy metals (zinc, cadmium and lead) on the growth rates of two polychaetes, Dinophilus gyrotilatus and Ophryotrocha laborica have been followed in laboratory experiments. Variations in the quality of "clean" sea water had effects as large as using 0.4 ppm of cadmium. (Institute for Marine Biology and Limnology, University of Oslo).

- 2.9 Studies of the regeneration of heavy metals from sediments in Oslofjord by the activity of animals are under investigation and are initially concentrated on the role of faecal pellets, which comprise 70% of the sediment, in accumulation and breakdown processes associated with heavy metals. (Institute for Marine Biology and Limnology, University of Oslo).
- 2.10 The experimental phase of studies on the ways and rate of uptake and excretion of cadmium, and its possible biological effects on the flounder was completed. The material is being worked up. (University of Oslo, Institute of Marine Biology and Limnology).
- 2.11 Growth (length) of algae in relation to nutrients, temperature, oil components, copper and zinc and growth (length) of Mytilus in relation to temperature, copper and zinc have been studied in 1977 (Zoological Dept. University of Trondheim).
- 2.12 Acute toxicity test on effects of metals and halogenated organics have been performed with algae, crustacea, molluscs and fish. (The Norwegian Institute of Water Research).

#### Poland

No report received.

#### Portugal

(C Lima)

Instituto Nacional de Investigação das Pescas,  
Secretaria de Estado das Pescas,  
Ministério da Agricultura e Pescas:

- "Étude du cycle annuel d'une lagune côtière, (Lagoa de Óbidos)
- Dans le cadre d'un système de surveillance continue (monitoring) du niveau de polluants dans le milieu marin et organismes aquatiques, on a fait la détermination du niveau de pesticides organochlorés et PCBs chez quelques espèces de poissons d'intérêt commercial, des côtes portugaises (Merluccius merluccius, Sardina pilchardus, Solea solea).
- "Étude d'un cas de mort de poissons, survenu dans l'embouchure de la rivière Sado, par suite de décharges des mines de pyrite de la région".
- Étude du "Delta de Faro-Olhão": aspects physiques, bactériologiques, chimiques.

Comissão Nacional do Ambiente,  
Secretaria de Estado do Ambiente:

- "Étude de modèles de prévision pour l'Estuaire de la rivière Tejo".

Centro de Geofisica das Universidades de Lisboa-Grupo de Oceanografia:

- "New computations and precipitations and evaporation over the Mediterranean Sea and some oceanographic implications".
- Hydrographic observations of the Canary current between 21°N and 25.5°N during March-April '74.

Comissão Executiva do Poligono de Acustica Submarina dos Açores  
Estado Maior General das Forças Armadas:

- Contrôle de la pollution de la rivièrè Lima et de la zone Atlantique adjacente.
- Études de surveillance de la côte nord du Portugal par suite d'un accident de pollution survenu avec le navire "Urquiola" près de Corunha (Espagne).
- En ce qui concerne les données demandées au sujet de l'extraction de sable et de gravier, nous ne sommes pas en mesure de les fournir, étant donné qu'il n'existe pas au Portugal un organisme qui centralise ces informations. Néanmoins nous sommes en train de recueillir des renseignements que nous enverrons dès que possible.

Spain

(J Ros)

Introduction

The Network for Monitoring the Quality of the Marine Environment (R.O.M.) originated with the need for knowing, with sufficient foresight to take action, the risk of the explosion of toxic phytoplankton species, which could affect the quality of the molluscs being cultivated off our coasts, in particular those of the Galician estuaries (rias).

With this in mind the Ministry of Commerce authorised, (December 1976), the necessary credits to establish on an experimental basis, a network of monitoring the quality of the Marine Environment which, in the first stage, would be concentrated in the Galician estuaries.

The importance of the coast to our country, not only from the viewpoint of fisheries but also from that of tourism and industry, stresses the need to protect the marine environment from changes which could affect the marine ecosystem, or prejudice any other legitimate use of the marine environment, tourism, navigation, industry, etc.

Bearing this in mind the Ministry of Commerce authorised (June 1977), the extension of the R.O.M. to all Spanish coastal waters, under the same experimental basis that it had in the first stage.

#### Functions of the R.O.M.

- To undertake a systematic and periodic surveillance of the quality of the Spanish coastal waters.
- To establish a systematic and periodic observation of certain groups of organisms, mainly phytoplankton and benthos.
- To alert the authorities in the case of the presence of species which could form an abnormal bloom (red tide) which could be toxic.
- To follow the evolution of the parameters which define the quality of sea water.
- To follow the evolution with time of the ecosystems studied in each area.
- To obtain a general view of the quality of the coastal waters and their evolution.

#### Objectives of the R.O.M.

- To have, at our disposal, an instantaneous alert system in the event of observing the presence of certain potentially toxic species, in the shellfish culture zones, or the dangerous concentration of certain contaminants, in marine organisms.
- To have available an alert system to enable us to take measures over a medium term, in the event that the observations of the quality of the marine ecosystem show a negative evolution, which could produce damage if no measures are taken.
- To allow us to establish environmental quality objectives for each usage of the sea water.
- To fulfil the international commitments derived from the conventions for:-
  - a) "The Prevention of Marine Pollution by dumping from ships and aircraft". Oslo 1972.
  - b) "The prevention of Marine Pollution from land-based source", Paris 1974."
  - c) "The Protection of the Mediterranean Sea against Pollution", Barcelona 1976.

#### Sampling Frequency

In general the samples will be collected once a month, and in the case of Galician estuaries and for monitoring the presence of potentially toxic phytoplanktonic species, this frequency will be at a minimum of, monthly in winter, fortnightly in spring and autumn, and weekly in summer.

### Collection of Samples

The water samples for the determination of the Class I Parameters will be taken with Niskin bottles. In each station 2 samples will be taken, one at one metre below the surface and the other at one metre from the bottom.

The samples for the determination of the other parameters must be taken following the specific method for each parameter.

### Treatment of the Samples

The samples for the determination of salinity will be taken to the laboratory in the normal glass bottle.

The determination of temperature, pH and dissolved oxygen, will be carried out on board, as usual.

The samples for the determination of material in suspension, must be filtered as soon as possible, the filters may be kept in a plastic envelope in the freezer.

The samples for the determination of chlorophyll "a" must be filtered on board as soon as possible. The filters will be kept in a glass tube with a screw-on top, wrapped in aluminium and kept in the freezer.

The sample for the determination of hydrocarbons in the water must be kept at 4°C in the same bottle as used for collecting the sample.

The samples for the determination of detergents in the water must be kept at 4°C in polythene bottles.

The samples for the determination of bacteria should be dealt with as soon as possible - within 8 hours.

The samples for the determination of heavy metals and organochlorine compounds must be dealt with following the given recommendations.

Parameter	Measuring unit	Type of Sample	Recommended procedure and instrument
1. Temperature	°Celsius	W	Reversing thermometer
2. Salinity	g/kg	W	Electrometrically (salinometer)
3. pH		W	Electrometrically (pH meter)
4. Dissolved oxygen	ml/l	W	Winkler
5. Suspended matter	mg/l	W	Gravimetry
6. Chlorophylla	mg/m <sup>3</sup>	W	Spectrophotometry
7. Nitrate	micro g/l	W	do.
9. Silicate	do.	W	do.
10. Phosphate	do.	W	do.
11. Hydrocarbons Dissolved Particulate	micro g/l mg/m <sup>2</sup>	W	do. Spectrofluorimetry Gravimetry
12. Detergents as Manoxol OT.	micro g/l	W	Spectrophotometry
13. Bacteri		W	Membranefilter
14. Heavy metals	mg/kg	M.O.	Atomic Absorbtion
15. Organochlorine compounds	micro g/kg	M.O.	Gas chromatography

Legend

W = sea water

M.O.= marine organism



### The R.O.M. Organisation

The Spanish Oceanographic Institute has been put in charge of the organisation, assembly and maintenance of the Network for Monitoring the Marine Environment.

The R.O.M. relies on the 7 coastal laboratories of the Spanish Oceanographic Institute: Vigo, Coruña, Santander, Palma de Mallorca, Mar Menor, Malaga, and Tenerife.

Each laboratory has a stretch of coast for observation and in each one, the most interesting sites have been chosen for sampling.

<u>The Vigo Laboratory</u>	: The Vigo Estuary the Pontevedra estuary.
<u>The La Coruña Laboratory</u>	: The Estuaries Arosa, Muros, and Ares.
<u>The Santander Laboratory</u>	: Bilbao, Santoña, Santander and Suances.
<u>The Balearic Island Laboratory</u> (Palma de Mallorca)	: Palma de Mallorca, Alcudia, Mahón, San Antonio de Ibiza
<u>The Mar Menor Laboratory</u>	: Tarragona, Delta del Ebro, Castellón, Sagunto, Valencia, Alicante, Cartagena, Mar Menor
<u>The Malaga Laboratory</u>	: Almeria, Motril, Malaga, Estepona, Algeciras y Huelva.
<u>The Canary Island Laboratory</u> (Santa Cruz de Tenerife)	: Santa Cruz de Tenerife, Los Cristianos

### Parameters measured

We have chosen a series of parameters bearing in mind their global and local importance and we have classified them in 3 categories, no particular priority being shown.

Category I - This category includes physicochemical parameters for sea water

1. Temperature
2. Salinity
3. pH
4. Dissolved oxygen
5. Suspended matter
6. Chlorophyll "a"
7. Nitrites
8. Nitrates
9. Phosphates
10. Silicates



Category II - These are specific parameters of marine pollution in water, in sediments and in marine organisms.

11. Hydrocarbons
12. Detergents
13. Bacterias: E.coli, faecal streptococci, and total coliforms.
14. Heavy metals
15. Organochlorine compounds

Category III - This category includes parameters of the communities and marine ecosystem.

16. Phytoplankton toxonomy
17. Phytoplanktonic species potentially toxic (Galicians estuaries)
18. Number of particles
19. Zooplankton biomass
20. Marine communities

Sweden

(L Thorell)

#### The Swedish West Coast

##### Biological investigations

1. The effects of changes in water quality on hard and softbottom ecosystems in the Kattegat and Skagerak were studied as well as the long time natural dynamic processes within marine bottom ecosystems. The hard bottoms were studied by SCUBA technique (the Kristineberg Marine Biological Station).
2. In 1977 investigations were started to evaluate the importance of shallow soft bottom for the production of fish and fishfood. (University of Gothenburg).
3. The reason for the appearance of big amounts of green algae (Cladophora) in the Laholm Bight was studied (University of Lund).

##### Oceanographic and chemical investigations

4. In order to calculate the in- and out-transport of plant nutrients, chloride, oxygen, and organic matter through the passage Gothenburg-Fredrikshaven hydro-chemical measurements made made regularly at this transect. (National Board of Fisheries).
5. Measurements on currents and water stratification were made in the south east of Kattegat by the Swedish Meteorological and Hydrological Institute (SMHI).

## The Oresund and the Baltic

### Biological investigations

6. The influence of the water quality on the bottom ecosystem was investigated in the Gulf of Bothnia (University of Umeå) in the Baltic proper (University of Stockholm) and in the Hanö Bight (University of Lund). The structure and dynamic of the bottom community were registered and the importance of abiotic factors was considered.

7. The abundance and seasonal fluctuations of some pelagic fish eggs and fish larvae were studied. The relationship between the size of the cod population and the changing oxygen concentrations was considered.

The primary production was measured in the Baltic and in the Gulf of Bothnia (National Board of Fisheries).

8. The nitrogen fixation by bluegreen algae and its importance for the nitrogen supply for the phytoplankton and the primary production was studied in coastal areas (University of Uppsala).

### Ecosystem studies and models

9. The Askö Laboratory, south of Stockholm, has concentrated most of its work on dynamics and energy flow in the Baltic ecosystem. The biomass and production of phytal, pelagic and benthic organisms and of fish have been studied. The findings are correlated with data on currents, temperature, and chemical properties of the water. A similar investigation made in the more coastal water of the Himmerfjärden. Some other projects are also carried out, for example an evaluation of air and satellite photos. A model has also been made by the Stockholm Institute of Technology.

10. A two-dimensional numerical model of the time-dependent estuarine circulation in the Baltic has been developed in order to understand physical processes essential to the Baltic ecosystem. This model will be used in studies of the spring phytoplankton bloom.

### Exchange processes and material transport

11. The Belt project is a joint Danish-Swedish study of the material balance and material transport through the inlets to the Baltic.

12. The water exchange in the Baltic has been studied by the Department of Oceanography at the University of Gothenburg. The deep water flow into the Baltic is of special interest.

13. The transport of bottom sediments within the Baltic was investigated (University of Uppsala).

14. In cooperation with other Baltic States the water exchange processes between different parts of the Baltic were studied. The transportation of dissolved and suspended matter was also calculated.
15. The transport and circulation of organic and mineral matter within the sediments and between the sediment and the water just above was studied. (University of Stockholm).
16. Investigations were made to estimate the exchange of material and heat between the Gulf of Bothnia and the adjacent waters (SMHI).

#### Oceanographic and chemical investigations

17. With the assistance of Coast Guard Personnel and vessels, routine hydrographic observations are made along the coast of Sweden in a joint project of the National Environment Protection Board, the Swedish Board of Fisheries and the Swedish Meteorological and Hydrological Institute.
18. Since 1969 chemical and hydrographical observations have been made by the National Board of Fisheries to study the stagnation of deep water of the Baltic. Research vessels visit the Baltic and the Kattegat four times a year. Data obtained for temperature, salinity, alkalinity, pH, oxygen, phosphate, total phosphorous nitrite, nitrate, ammonia, total N, silicate, absorption at 370 nm, hydrogen sulfide and occasionally chlorophyll, oil, urea-N, total organic carbon and tritium.

In studies of the Gulf of Bothnia similar data are obtained twice a year.

19. In addition to the above-mentioned study, hydrographic and hydrochemical investigations of the winter situation in the Gulf of Bothnia have been carried out since 1974 with the help of ice-breakers, coast guard vessels and research vessels. Both chemical and plankton analyses are performed.

#### Pollution

20. The concentration of PCB and heavy metals were measured in the sediments in the Baltic proper and in the Gulf of Bothnia.
21. By field studies the ecological effects of oil and oil detergents were investigated in the Baltic.
22. Bacterial investigations of the bottom sediment of sandy beaches have shown that coliforms occur in high numbers in or around the water line (the University of Lund).
23. Observations of the effects on marine organisms of cooling water from nuclear power plants are made by the National Environment Protection Board.
24. Since 1972 routine analyses of the oil content of water from the Baltic, the Kattegat and the Skagerrak have been made by the National Board of Fisheries.
25. The DDT and PCB levels in seals have been determined since 1969 by the Swedish Museum of Natural History in collaboration with the Special

Analytical laboratory of the National Environmental Protection Board. Herring, cod, and guillemot are analysed for DDT, PCB, mercury, and cadmium.

26. Since 1967, the Swedish National Food Administration has determined the levels of DDT and its metabolites, PCB, dieldrin, BHC, lindane, hexachlorobenzene and pentachloroanisole in fish flesh, liver of cod and turbot, crayfish and canned fish products. A survey of methyl mercury levels in fish from Swedish waters started in 1966 and is still in progress.

27. The National Environment Protection Board is investigating the effect of heavy metals on ecosystems of soft bottoms. The influence of cadmium on the sexual maturation of Pontoporeia affinis has been studied.

28. At several places along the coast studies of spreading and control of waste water outlets have been made.

#### United Kingdom

#### England & Wales

(P Wood)

#### Monitoring Activities

#### Fish and Shellfish Quality

Following the success of the 1975/76/77 sampling programmes in providing material to allow an adequate assessment of the benchmark levels of contaminants in all major fish and shellfish species landed in England and Wales, the routine monitoring activities at Burnham were reduced to a core programme designed to provide continuity with the previous work and to follow long term trends. The basis of this were samples of cod, plaice and mussels collected from ports and fisheries around the coast and analysed for the usual range of organochlorine compounds and trace metals. The remaining analytical capacity was used in a number of special programmes. These included the study of hot spot areas in terms of either particular contaminants or species highlighted in previous work: more detailed examination of dumping grounds both sediments and biota; new species of fish which have either increased substantially in commercial importance (mackerel) or have the potential for significant exploitation (blue whiting, spider crabs, etc.). In order to study the behaviour of contaminants with increasing age, the 1976 year class of cod will be followed for as long as possible. In the main surveys the samples were analysed for copper, zinc, lead, cadmium, mercury, PCBs and several of the more common organochlorine pesticides, e.g. dieldrin, HCH, DDT, etc. In addition a number of special surveys were undertaken concentrating on particular contaminants, e.g. arsenic in a variety of fish and shellfish from the Humber estuary; cadmium in crabs from major UK fisheries. A repeat of the 1972 Bristol Channel intertidal shellfish survey was performed, the samples being analysed for cadmium, lead and

zinc, the results of which indicated a decline in metal concentrations in intertidal biota. Also in this area a special mercury survey was performed using 10 finfish species collected during an intensive sampling programme in Swansea Bay.

There have been two major international commitments this year. An ICES programme which was catered for by the existing UK programme with the addition of some extra cod and flounder samples from the Thames estuary and a commitment under Paris to an Anglo-French channel study involving two species of finfish and three species of shellfish.

The 1970-73 fish and shellfish report is due for publication very shortly. Reports for 1974 and 1975 are in preparation and it is hoped these will be available by the end of 1978.

International requirements have again involved the analytical chemistry group in intercalibration exercises for petroleum hydrocarbons, metals and organochlorine compounds. The hydrocarbon exercises are the first of the type to be undertaken by this laboratory and the performance of the laboratory vis-a-vis other participants has been good. The results which are available from other intercalibration exercises show no deterioration in performance.

#### Hydrocarbon Surveys

The detailed investigation of an estuary subjected to discharges from a refinery has been completed and the knowledge gained in analytical techniques and the characterisation of non-biogenic hydrocarbons has provided a foundation for the development of a monitoring programme around the North Sea Oil rigs. The "Bravo blow out" from the Ekofisk oil field afforded an ideal opportunity to study a pollution incident under truly field conditions and in the course of making a contribution to the Norwegian and international scientific studies of this incident valuable experience was gained for the forthcoming North Sea programme.

#### Hydrocarbons in Shellfish

Depuration experiments with clams contaminated with Benzpyrene have shown that after initial purging, the half life, under laboratory conditions of holding in filtered river water, of a concentration of 6-7  $\mu\text{g/kg}$  BaP was 4-7 weeks and background levels of 2  $\mu\text{g/kg}$  would have been reached in 10-14 weeks.

As an extension of the Anglo/French channel study, mussel samples from a number of sites along the south coast have been analysed for their petroleum hydrocarbon content including that of poly-nuclear aromatics. The preliminary results indicate a gradient from east to west with high spots associated with areas receiving substantial industrial inputs.

#### Analytical Chemistry

A number of new items of chemical analytical equipment have been added to those already available. 2 capillary G.C.s are now in use mainly devoted to the petroleum hydrocarbon programme. In addition to these G.C.s, analytical capability for petroleum hydrocarbons has been further expanded by the purchase of a UV fluorescence spectrophotometer. The requirement for metal



analysis, especially mercury, continues to be large, the automated mercury method developed last year has been proved so successful that a second similar system has been installed.

#### Method Development

The development of cadmium and lead analysis using the heated graphite furnace continue, attention has been turned from the use of the straight acid/peroxide matrix to an APDC/MIVK extraction matrix which is beginning to yield fruitful results and it is hoped that this will allow us to lower out detection limits by a factor of 10 for lead and 100 for cadmium.

The distribution of sewage sludge after disposal either from pipeline discharge or dumped from vessels has so far been investigated primarily by hydrographic techniques and elevation of the organic and trace metal content of the surrounding sediments. These techniques, however, lack specificity and the use of coprostanol, a specific constituent of sewage, is being investigated as a routine tracer material for these discharges. Petroleum hydrocarbons although subject to routine analytical methodology provides the most active area of development. Methods for the analysis of the carcinogenic and possible carcinogenic components of crude and refined oils and pyrolysis products are at present being studied.

#### Monitoring of areas used for dumping of wastes

To supplement the statutory controls on the dumping of wastes at sea, under the Dumping at Sea Act 1974, monitoring of the areas used for the disposal of approved wastes continues.

The primary components of this monitoring programme, which is concentrated on areas receiving sewage sludge, liquid industrial wastes, mineral wastes and dredged spoils are:-

- i) Techniques to establish the dispersion paths and ultimate fate of the waste. Hydrographic investigations involving moored current meter emplacements, seabed drifter releases and 26 hr surface and bottom water current measurements are continuing in several areas (off the Rivers Humber, Tees, and Tyne and in the Bristol Channel). The dispersion of dumped sewage has also been followed successfully through tracing the sewage bacteria in sediments. Chemical analysis of sediments for organic substances and trace metals continues to identify sites of accumulation in sediments.
- ii) Techniques to establish the biological effects on the benthos have been further developed and have been applied to areas used for sewage sludge and mineral waste disposal. The data are analysed by computer, using classification and ordination techniques, permitting a more objective and quantitative assessment of biological effects than was possible using earlier techniques. Correlations between the faunal data and changes in the sediment attributable to dumping are statistically validated. Five areas have now been studied by these techniques (3 sewage sludge, one colliery waste and one flyash dumping area).



- iii) The metal levels found in commercially exploited fish and shellfish near to dumping areas are monitored, and ancillary field studies are also being undertaken to investigate the relationship between the metal levels in sediments and certain benthic species.
- iv) Water quality surveys (for nutrients and metals) have been conducted in one dumping area, and two more areas will be surveyed later in 1978.

#### Microbiological tracing of sewage sludge

Techniques for the estimation of coliforms and E.coli in bottom sediments have been further developed to study the dispersion of sewage solids from dumped sewage sludge. Using a simple membrane filtration technique, an extensive network of stations are sampled and examined at sea. The results obtained are in good agreement with seabed drifter and radioactive trace studies, and suggest that the use of bacterial indices may be a useful means of estimating the distribution of sewage sludge solids in bottom sediments.

#### Sedimentological studies

Most studies completed this year have been a part of the ongoing programme of monitoring the effect of dumping in the major dumping grounds off the UK.

Each sediment survey consists of seabed sampling (a network of at least thirty stations) with a Day grab and/or box corer, observations of hydrographic/suspended sediment characteristics (26 hour hydrographic observations, continuous current-meter data, seabed drifter releases), and acoustic surveys (side/sector scans, echo sounding).

Seabed samples are analysed in the laboratory to determine particle-size characteristics, C/N and trace metal content - the latter (chemical) characteristics are determined on two size fractions of the sediment (90-500  $\mu$ m and <90  $\mu$ m). These data together with the biological information, are fed into a data bank, from where statistical analyses can be performed.

Over the past year, the collection of necessary raw data from all of the dumping grounds has been completed. Surveys from Exeter, Plymouth and the north-east coast grounds (Blyth, Tyne, Wear) have been worked up, and reports are in press together with introductory and methodology reports.

Using a combination of published data and MAFF survey data, it has been possible to obtain a reasonably detailed picture of the physical behaviour of sediments at each of the dumping sites, together with a clear description of the distribution of C, N, Hg, Cu, Cd, Cr, Zn, Ni, Pb associated with the sediments.

#### Benthic populations in dumping areas

Detailed benthic investigations of the major areas of waste disposal have continued. Reports are in press on benthic investigations conducted on the sewage sludge dumping grounds off Exeter and Plymouth, and in the outer

Thames estuary, and on the dumping areas off the north-east coast of England. These studies have utilised the computer programmes now available for a fully quantitative and objective analysis of the faunal data, including classification and ordination techniques, and the correlation/regression of biological characteristics with physical and chemical properties of the sediments. These techniques have allowed more subtle effects of sediment changes on the characteristics of the fauna to be identified than with previous techniques.

#### Mineral Extraction

Investigations continue into the effects on, and subsequent recovery of, benthos, following marine gravel extraction off the east coast of England. (No further Lithothamnium studies have been made or are planned).

#### Toxicological Studies

##### Laboratory tests of industrial wastes

Routine static tests to determine the acute toxicity of industrial wastes using Crangon and Agonus have continued.

##### Dispersant and oil toxicity

New laboratory tests developed to determine the acute toxicity of oil dispersants, both as used at sea and on beaches have been applied to over 50 products.

The sea test involves exposing Crangon to a 1:1 mix of oil and dispersant (or 10:1 in the case of concentrates) maintained in suspension by agitation, for 100 minutes followed by a 24 hour recovery period in clean water. For the beach test, Patella, attached to 'Perspex' plates are sprayed with neat dispersant and exposed in air for six hours before being washed and given a 72 hour recovery period in a tidal seawater system. Further work has been carried out on the full toxicity response curve of the test organisms.

##### Toxicity of pure compounds

Short-term tests in a flow through system are being used to determine the acute toxicity of pure compounds and other compounds likely to reach the marine environment (e.g. drilling muds, surfactants, chemicals carried in bulk).

##### Sub-lethal studies

Long-term studies with Crepidula have established a basal feeding regime for reproductive success in the laboratory and have investigated the effects of feeding stress on various measurements of physiology, biochemistry, growth and reproduction. An experiment to study the effects on growth and reproduction of administered levels of 3-33 parts per 10<sup>9</sup> of inorganic mercury is being conducted with regular monitoring of the actual levels of mercury in water, algal food, detritus and tissues.

## Microbiology

### Virology

MS2 bacteriophage is to be used as a model for polio virus to establish methods then experiments will be run to look at the uptake and removal of polio virus by molluscan shellfish and the effects of purification and heat processing on viruses. Work has now started on this.

### Laboratory studies

A frame has been built to hold three types of sediment over which sewage sludge can be passed slowly to allow it to settle out on the sediments. It is hoped that much information can be gathered from the frame including survival of bacteria in seawater, behaviour of different bacterial populations, comparison of methods using material from the frame and ways to improve recovery methods.

### Field Investigations

Bacterial investigations of shellfish and water has continued to assess pollution in areas where shellfish are cultivated and standards are required for sale or potential markets.

### Public Health Aspects

Purification plants using ultra violet light have continued to be constructed. Laboratory studies have continued in the cooling and handling of cooked cockles with marked improvement in the reduction of the total flora of the final cooked product.

### Dinoflagellate toxicity

Monitoring of toxicity levels (PSP) in mussels was again continued in 1977 from March to early August. 135 samples were taken. Low level toxicity was detected at Budle Bay in May (188mu/100 g) and was evident at stations between Berwick and Scarborough by the end of the month. Redcar exceeded the safe level 1624mu/100 g Saltburn 1792mu/100 g and Scarborough 1020mu/100 g. The first week in June Whitby registered 1344mu/100 g and Scarborough 970mu/100 g. Thereafter toxicity occurred making a total of 43 toxic samples, of these 8 exceeded the safe limits of 400mu/100 g.

Viewing the results from all stations sampled and comparing phytoplankton and toxic observations Gonyaulax was the only genus represented in all stations at the time when toxicity reached maximum levels.

Peridinium spp and Exuviella sp were also present often exceeding Gonyaulax spp.

Gonyaulax and Peridinium spp disappeared as toxin levels declined but Exuviella sp persisted.



Scotland

(A D McIntyre)

1. Shellfish and public health

A service for advice on purification and for analysis of shellfish and water for selected pollution indicators has been maintained.

2. Sewage

Studies of the effects of sewage sludge dumping have been continued, both on the grounds themselves, and in experimental situations. In the experiments, the changes caused by sewage sludge on the sediment and benthos in underwater enclosures have been examined and the first cycle of observations completed.

3. Metals

Intercalibration Samples of flour (20 g) were circulated to 18 laboratories within ICES countries in June 1977 as part of an inter comparison for cadmium and lead. By the end of January 1978 results from 12 laboratories had been received. The data have been analysed and a report will be presented to the appropriate Working Group in May 1978.

Monitoring metals in fish Following the completion of an extensive national survey in 1976, the DAFS laboratory has been concentrating on those commercial species shown to contain elevated levels of toxic metals. Particular attention was paid in 1977 to halibut, common ling, blue ling and blue whiting and to the relationship between mercury levels and size, weight, age and geographical location. Results on the halibut and on arsenic have been submitted to ICES (C.M. 1977/E:39 and E:38, respectively). To evaluate the use of mussels as a tool to monitor background levels of contaminants in the environment, an extensive programme of mussel collection along the entire coast of Scotland was carried out, with emphasis placed on the major estuaries and areas of industrial activity. A report of this work will be submitted to ICES in 1978.

In situ bioassay studies In 1976 the laboratory established a series of moored cages containing specially selected mussels in the Firth of Forth to examine the levels of mercury in sea water contaminated by industrial activity. The work was continued in 1977 and shows that the levels of mercury in the mussels are proportional to the length of exposure time, and reflect the mercury levels in the water.

Atmospheric studies Measurements of the atmospheric deposition of a range of metals in rain water made at six sampling sites round the Firth of Forth were completed in 1977 and the results presented to ICES.

Toxicity testing A number of tests were carried out on biocides used by the oil industry to aid decisions on how water containing these substances may be discharged into the sea.

Experimental studies During the summer of 1977, further experiments were carried out to investigate the movement of mercury in the water column following its addition as inorganic mercury. The large plastic bag facilities at the Loch Ewe field station were used for this work.

#### 4. Oil

In collaboration with Torry Research Station, a variety of studies have been made in relation to North Sea oil. These include detailed measurements of the distribution of selected oil components among the main compartments of the ecosystem (surface film, water, sediment, biota) on a line between the Firth of Forth and the Forties Field. Studies have also been continued at Sullom Voe, with special emphasis on the hydrography to provide an understanding of the likely dispersal of spilled oil. On the experimental side, the plastic bags were used to examine the effects of oil on plankton and fish larvae, and also to look at the fate of oil in the water column and its rate of sedimentation to the bottom.

#### 5. Work at Pitlochry

The six-monthly survey of organochlorine residues in cod, whiting, plaice and herring from the Firth of Clyde, Moray Firth, Firth of Forth and Ling or Viking Banks, using random samples of fish from commercial catches, was continued during 1977. The only area showing any evidence of a change in contamination levels was the Firth of Clyde, where concentrations of DDT and PCB were lower than in earlier years in cod, plaice and herring, but not in whiting.

Herring were sampled in the Firth of Clyde on several occasions during 1976, the individuals being selected for size and sex and analysed individually for dieldrin. The results, which were completed in 1977, indicated that there was a distinct seasonal trend in dieldrin concentrations in muscle tissue when calculated on a lipid basis, being at a maximum of 1.43 mg/kg in April but between 0.57 and 0.69 mg/kg between June and September, rising again in October and November. The fat content was at a minimum (2.6%) in April and highest (13.0-14.0%) from July to September. The mobilisation of fat reserves in the winter seems to result in an increase in the dieldrin concentration in the remaining fat, although there may have been some loss from the fish at the same time, as the concentration in the muscle tissue was lowest in April (0.033 mg/kg). Muscle concentrations showed a trend upwards during the summer, reaching about 0.09 mg/kg by November. These results confirm that the contamination level varies with the time of sampling, although there is less variation over the period June-September for herring. The possibility that discharges of the contaminant also varied over the period of study cannot be disregarded, however.

The herring samples taken in the same area every summer from 1972 to 1975, selected as far as possible for age and sex and analysed individually in the OECD monitoring programme, have shown evidence of significant decreases in dieldrin, DDT, and PCB over this period. The data were analysed by a stepwise multiple regression procedure which adjusts for the influence of weight, length, age and fat content. Outliers which lay beyond the arbitrarily selected limits of  $\pm 36$  were rejected before regression analysis. The downward trends in PCB, DDT, DDE, TDE, and dieldrin were all significant

at the 1% level, and as expected the fat content was strongly correlated with organochlorine concentration (1% significance level). There was evidence of a weak correlation of PCB with age, but no significant correlations of any residues with weight or length.

A survey of organochlorine residues in mussels (Mytilus edulis) sampled at over 100 sites around the coast of Scotland was completed, and a paper will be submitted to the Committee giving a detailed account of the results. Briefly, a number of individual locations were identified where the concentrations of dieldrin, DDT, and PCB were significantly above the general background level, and the concentration ranges mostly spanned three orders of magnitude. Several of the locations were already recognised as polluted, but some new sites of contamination were identified as a result of the survey.

The analysis of a large number of grey seal (Halichoerus grypus) organs and tissues obtained from a wide age range of seals during a cull on the Farne Islands in 1975 was completed for both heavy metals and organochlorines. A report giving the results will be submitted to the Committee.

U.S.A.

(J B Pearce)

UNITED STATES MARINE POLLUTION STUDIES; Northwest Atlantic

Extensive experimental and field research concerned with marine pollution was conducted between Cape Hatteras and the Canadian boundary during the period January 1977-February 1978. As noted in last year's committee report, the Bureau of Land Management (BLM), U. S. Department of Interior, funded a continuing study of the Middle Atlantic Bight in anticipation of exploratory oil drilling and eventual production. The objectives of the investigations were given in the committee report for 1976-7.

Elements of the Virginia Institute of Marine Science (VIMS) and the National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), were involved in the BLM study during 1977-8.

Research conducted by VIMS under the direction of Dr. D. F. Boesch focused on the continental shelf and slope of the Middle Atlantic Bight and the Chesapeake Bay estuarine system. Offshore research included studies of the distribution, sediment relationships, and community structure of bottom feeding fishes, large invertebrates (captured by dredge), macrobenthos (sampled by grab), meiobenthos and foraminifera. The existence of a unique shelf break community was discovered. The distribution of benthos on the continental shelf was found to be a mosaic response to the complex topography of the shelf. Communities of macro- and meiobenthos in topographic swales are very distinct from those on ridges and the more exposed coarser sand bottoms. Concurrent investigations of trace metals and petroleum hydrocarbons in sediments and benthic invertebrates showed that the areas in which offshore oil and gas development is imminent are relatively pristine. Predominant hydrocarbons are of a pyrolytic origin and have apparently been carried seaward in the atmosphere.



The effects on the benthos of severe hypoxia (low dissolved oxygen) which occurred on the inner shelf off New Jersey were investigated by VIMS and the NMFS and the recovery process was followed. Populations of echinoderms and crustaceans were virtually eliminated in areas which had experienced the anoxia in 1976. Although some species of mollusks and annelids were affected, other species survived. VIMS scientists reported that species with planktonic larvae quickly recolonized in affected areas, but those without planktonic dispersal, particularly the peracarid crustaceans, i.e. amphipods and isopods, had not recovered after one year. Other species, including two polychaetes and a cerianthid anemone, occurred opportunistically after the disturbance. Recovery from the disturbance was also investigated by VIMS by following recruitment in azoic sediments placed on the outer shelf. Surface dwelling macrobenthos, including the diverse populations of tube-dwelling amphipods, repopulated within a few weeks but repopulation by more deeply burrowing forms lagged. The opportunistic Capitella capitata, which usually is not found in the area, established quickly in the azoic sediments.

Research on Chesapeake Bay macrobenthos was continued by VIMS scientists, focusing in the lower York River estuary. Studies of the long-term dynamics of mud-bottom macrobenthic communities continued. Other investigations documented the effects of petroleum contamination of sediments near an oil refinery on the macrobenthos.

Personnel of the Sandy Hook Laboratory, Northeast Fisheries Center, NMFS, worked up historical (1974) benthic samples collected from stations in areas proposed for oil exploration and development. The resulting benthic data are being used in multivariate analyses to relate benthic community structure to sediment type, heavy metals in sediment and other factors. The data and analyses provide a benchmark for more recent benthic studies in areas proposed for oil development.

The College of Marine Sciences, University of Delaware, conducted studies in Delaware Bay and the Middle Atlantic Bight off the Bay as well as at the Georges Bank. Studies in Delaware Bay emphasized seasonal changes in feeding types of benthic organisms at areas proposed for oil tanker lightering. It was found that finer sediments were dominated seasonally by deposit feeders; coarser sediments contained both deposit and suspension feeders. Delaware personnel were also involved with an investigation of seasonal fluctuations of benthic assemblages at sites proposed for large ocean outfalls for wastes.

Biologists (planktologists) at the University of Delaware investigated a major frontal system in waters of lower Delaware Bay and the adjoining continental shelf, as a model illustrating the role such zones can play in concentrating trace metals and making them available to entrained organisms. Relative to this system, results revealed that high concentrations of zinc, cadmium and copper occurred in the dissolved fraction and these could be traced to the particulate fraction and related to elevated concentrations in zooplankton tissue. Zooplankton and selected macrobenthic organisms were also collected from Georges Bank in the North Atlantic Ocean. In general, analyses of zooplankton and macrobenthic populations reveal large geographic variations with generally higher concentrations of seven metals occurring at nearshore stations as well as associated with the shelf-slope frontal system.

The Marine Ecosystems Analysis (MESA), New York Bight Project, NOAA, completed much of its field work in 1977 and has commenced synthesizing observations across disciplinary lines. Studies have emphasized: 1) the cycling of carbon, oxygen, and nitrogen in the Bight (relative to plankton dynamics and oxygen depletion events), 2) identification and measurement of the most significant contaminants in the Bight, 3) the cumulative effects of environmental stress, and 4) the transport patterns of dissolved and particulate materials. Such studies are essential in understanding the 1976 anoxia problem. A panel of experts has compiled available information to document the probable significance of contaminants in the Bight from the standpoints of public health and ecosystem impacts. Several consequences of environmental stress have been documented and efforts made to relate some particular stress responses to their causes. A diagnostic model of current transport has been partially evaluated. Work has begun to characterize the conditions under which fine sediments are resuspended by bottom currents. Such studies will be of importance in assessing the impacts of large scale, offshore excavation of marine aggregates and other mineral recovery activities, on living marine resources. Scientists of the Sandy Hook Laboratory, NMFS, provided significant portions of data to be used in MESA syntheses.

Experimental research in the field and laboratory has been emphasized by personnel of the U. S. Environmental Protection Agency (EPA), Environmental Research Laboratory, Narragansett, Rhode Island (ERL-N). The ERL-N Marine Ecology Research Laboratory (MERL), together with an inhouse ERL-N study on microcosms, is attempting to duplicate real ecosystem stresses in small and mid-scale, experimental enclosed estuarine systems. Operated by a multi-disciplinary, multi-institutional consortium, MERL has spent most of this year implementing and testing the systems for accurate mimicry of physical, chemical and biological phenomena. A device to observe, measure, and analyze the motion of organisms as it is altered by environmental pollutant exposure has been developed and is undergoing testing as a means to detect sublethal pollutant effects. Called "Bugwatcher", the device consists of a television scanner computerized to detect and analyze 2-dimensional motion for statistically significant changes in direction, velocity, and angular velocity. It is used in controlled, experimental exposure systems.

Mussel Watch, a program of monitoring biological responses to chemical pollutants, has become international in scope this year. The U. S. portion of the program, operated by ERL-N, has measured chlorinated hydrocarbons, petroleum hydrocarbons, transuranics, and heavy metals in mussels or oysters at 100 stations around the coastline of the continental U. S. CEAS (Coastal Ecosystem Analysis Survey), initiated this year, was designed to integrate closely with the National Marine Fisheries Service's Ocean Pulse program. It traces pollution effects upon biota and sediments from the headwaters of an estuary out to the open ocean, and has direct application to domestic and industrial waste disposal permitting activities of EPA as well as dredging and filling permits issued by the Army Corps of Engineers.

Scientists at the NMFS Milford (Connecticut) Laboratory, have continued their research to ascertain the sublethal effects of heavy metals on larval and adult shellfish and finfish. Using physiological and biochemical measurements obtained in constant flow diluter aquaria, they have established physiological responses to low levels of heavy metals. Measurements made at the NMFS Narragansett, Rhode Island, Laboratory have revealed the effects of oil on larval and juvenile finfish. Behavioral research conducted at the NMFS Sandy Hook Laboratory resulted in significant findings in regard to changes in the behavior of macrocrustaceans and finfish, as mediated by temperature change and petroleum.

In the Gulf of Maine the U. S. Fish and Wildlife Service (FWS) is conducting a study to develop a holistic understanding of the Maine coastal ecosystem from Cape Elizabeth (Portland) to the Canadian border. The concept is to assemble and present all existing information describing how the coastal ecosystem functions as a whole. Types of information to be included are biological, climatic, socioeconomic, hydrographic, geologic, geochemical and other data which relate to natural changes and man-induced stress. The characterization will be presented in atlas form with supporting narratives. The intent is to provide a better understanding of ecological relationships to people making resource management decisions affecting fish and wildlife resources. A test characterization of the Kennebec-Sheepscot estuaries was completed in March. Methods developed by this test will be applied to the entire study area.

During 1977 the Northeast Fisheries Center implemented its new environmental assessment program, Ocean Pulse. This program is designed to integrate and coordinate the coastal and marine environmental assessment activities of NMFS with those of other federal agencies and universities. The Ocean Pulse program emphasizes extensive cruises during which physiologists, biochemists, pathobiologists, geneticists, ecologists and behavioral scientists perform standard measurements at selected sampling strata. The sampling strata include areas known to be heavily impacted by contaminants as well as portions of the shelf that are pristine or relatively free of pollution. Three Ocean Pulse cruises have already been conducted to the Deepwater Dumpsite 106 located approximately 175 kilometers seaward from New York Harbor. Data from these cruises are being worked up for reports and publications.

U.S.S.R.

(S A Patin)

No relevant information available.

